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THE

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MEASURES OF DOUBLE STARS DISCOVERED AT CORDOBA.

By Prof. S. Glasenapp.

Last summer, 1890, I was in Gourzonff, near Yalta, Crimea, South Russia, and carried there a six-inch refractor with the special intention of measuring double stars. During three months I succeeded in obtaining 881 measures of more than 400 double stars. Among them I observed 14 double stars discovered by Gould in Cordoba, and recorded in the *Uranometria Argentina*. I have not seen that any measures of them have been published.

Gourzouff is a pretty place on the border of the Black sea, situated at a distance of ten kilometers east from Yalta. The geographical coordinates of my place of observation are:

$$\phi = +44° 32'.9$$
$$L = 2^h 17^m 8^s.6 \text{ E. Greenw.}$$

The diameter of the object-glass is 160^{mm}, and the magnifying power = 267. A revolution of the filar micrometer is equal to

$$r = 22''.1736 - 0''.0017.t$$

where t is the temperature in centigrade degrees.

I have tried to measure each double star in two different positions of the instrument: 1), when the refractor is at the east of the pier; and 2), when it is at the west. Since Gould's double stars are near the horizon for the latitude of Gourzouff, it was necessary to take into account the effect of refraction on the position-angle and the distance. All the measures are made very near to the meridian.

The following table contains:

1. The current number.
2. The epoch of observation in parts of the year.
3. The position of the instrument: o — when the instrument is west of the pier; w — when it is east of the pier.
4. The hour-angle of the observed star.
5. The temperature centigrade.
6. The images: the best ones are noted by 1, and the bad ones by 4 and 5.
7. The magnitudes of the components.
8. The observed position-angle θ.
9. The refraction in θ.
10. The observed distance σ.
11. The refraction in σ.

Each observation of position-angle consists of four measures; two of them made with a positive rotation of the micrometer, and the two other ones with a negative rotation. Each observation of distance is the mean of two measures of the double distance between the components.

The positions of the stars are given for 1890.0.

No.	Epoch	T	h	t	i	Magnitudes	θ	Refr	σ	Refr
1.	G. 271 *Centauri.*			$\alpha = 13^h\ 12^m\ 36^s$,			$\delta = -35°\ 9'$.	L. 5682.		
			h			M M			″	″
	1890.120	w	0.7	+20.6	3	7.2–10.3	356.56	+0.11	–	–
	.125	o	0.8	+13.2	2	7.3–10.0	351.90	+0.15	12.73	+0.11
2.	G. 370 *Hydrae.*			$\alpha = 14^h\ 6^m\ 28^s$.			$\delta = -26°\ 45'$.			
	1890.390	o	23.9	+16.0	1	6.0– 8.0	232.89	−0.07	(1.2)	–
	.398	w	0.4	–	3	simple	–	–	–	–
	.406	w	0.5	–	1	simple	–	–	–	–
	.428	w	0.2	–	2	simple	–	–	–	–
3.	G. 339 *Centauri,*			$\alpha = 14^h\ 13^m\ 57^s$.			$\delta = -11°\ 55'$.	L. 5891.		
	1890.406	o	0.4	+18.2	2	7.0– 9.0	211.54	−1.06	78.81	+2.88
	.409	w	0.3	+18.2	2	8.0– 9.5	212.68	−1.06	77.51	+2.62
4.	G. 380 *Centauri,* AB,			$\alpha = 14^h\ 17^m\ 55^s$,			$\delta = -32°\ 51'$.	(β 347).		
	1890.428	w	0.6	+11.5	2	6.0–10.5	315.62	+0.16	13.12	+0.05
	.431	o	0.3	+16.5	2	6.0–10.0	323.89	+0.16	–	–

This star was discovered independently by Mr. Burnham, and registered under the no. 347.

No.	Epoch	T	h	t	i	Magnitudes	θ	Refr.	σ	Refr.
5.	G. 380 *Centauri*, AC			$\alpha = 14^h\ 17^m\ 55^s$,		$\delta = -32^\circ\ 51'$.				
	1890.428	*w*	0.7	+14.1	2	6.0– 9.2	243.98	−0.14	58.17	+0.14
	.431	*o*	0.4	+16.5	2	6.0– 9.3	242.62	−0.14	58.29	+0.10
6.	G. 78 *Lupi* (f).			$\alpha = 15^h\ 11^m\ 8^s$,		$\delta = -29^\circ\ 41'$.				
	1890.403	*o*	23.6	–	3-4	4.0– 8.0	nf	–	–	–
	.417	*w*	0.9	–	2	– –	–	–	–	–
						Impossible to measure.				
7.	G. 126 *Lupi*.			$\alpha = 15^h\ 36^m\ 58^s$,		$\delta = -41^\circ\ 28'$.				
	1890.398	*o*	0.1	–	1	7.0– 9.0	357.36	+0.13	(1.0)	–
	.403	*w*	0.1	–		impossible to measure.				
	.406	*w*	0.3	–	1	7.0– 9.0	351.92	+0.33	(1.0)	–
8.	G. 28 *Scorpii*.			$\alpha = 16^h\ 2^m\ 31^s$,		$\delta = -32^\circ\ 21'$.		Br. 5613.		
	1890.422	*o*	0.0	+13.9	3	6.5– 7.0	267.79	−0.01	6.69	–
	.425	*w*	0.2	+12.6	2	7.7– 7.5	265.18	−0.04	7.02	–
9.	G. 62 *Ophiuchi*,			$\alpha = 16^h\ 50^m\ 36^s$,		$\delta = -19^\circ\ 22'$.				
	1890.406	*w*	0.9	+17.0	2	6.7– 7.0	232.18	−0.03	4.49	–
	.409	*o*	23.8	+17.7	1	6.7– 7.3	231.38	−0.03	4.65	–
10.	G. 177 *Scorpii*.			$\alpha = 17^h\ 44^m\ 8^s$,		$\delta = -30^\circ\ 31'$.				
	1890.422	*o*	0.2	+13.0	3	7.3– 8.5	190.97	−0.03	9.68	–
	.428	*w*	0.0	+13.4	3	7.0– 8.4	190.22	−0.01	9.45	–
11.	Ll. 33612, AB. C.			$\alpha = 18^h\ 12^m\ 13^s$,		$\delta = -18^\circ\ 40'$.		(β 639).		
	1890.494	*o*	0.6	+25.4	1	7.4– 8.0	50.84	−0.03	16.75	−0.01
	.496	*w*	0.2	+26.0	2	7.0– 7.5	51.55	−0.03	16.58	+0.01

This star was discovered independently by Mr. BURNHAM in 1878.

No.	Epoch	T	h	t	i	Magnitudes	θ	Refr.	σ	Refr.
12.	G. 70 *Sagittarii*.			$\alpha = 18^h\ 22^m\ 6^s$.		$\delta = -26^\circ\ 39'$.				
	1890.494	*o*	0.9	+25.1	2-5	7.3– 8.0	182.57	+0.02	11.63	+0.12
	.502	*w*	0.5	+23.5	3	6.2– 7.4	182.79	+0.09	11.73	+0.11
13.	G. 36 *Cor. austr.*,			$\alpha = 18^h\ 53^m\ 39^s$,		$\delta = -37^\circ\ 13'$.				
	1890.538	*o*	0.2	+30.2	2	7.0– 7.2	282.48	+0.12	11.69	+0.01
	.551	*w*	0.5	+26.6	3-4	6.5– 6.8	282.50	+0.09	11.51	+0.01
14.	G. 135 *Sagittarii*.			$\alpha = 18^h\ 57^m\ 36^s$,		$\delta = -23^\circ\ 4'$.				
	1890.521	*o*	0.1	+17.1	3	7.0– 8.2	306.75	+0.04	7.58	–
	.535	*w*	0.5	+30.2	2	7.3– 8.6	308.02	+0.05	7.35	–

RESULTS OF MICROMETRICAL MEASURES OF GOULD'S DOUBLE STARS.

No.	Star	α 1890	δ	θ	σ	Magn.	Epoch	No. nights
		h m s	° ′	°	″			
1	G. 271 *Centauri*	13 42 36	−35 9	351.36	12.84	7.2–10.1	1890.42	2 . 1
2	G. 370 *Hydrae*	14 6 28	−26 45	232.89	(1.2)	6.0– 8.0	.39	1
3	G. 389 *Centauri*	14 13 57	−41 55	211.05	80.91	7.5– 9.2	.41	2
4	G. 380 *Cent.* AB (β 317)	14 47 55	−32 51	319.91	13.47	6.0–10.2	.43	2 . 1
5	G. 380 *Cent.* AC	14 47 55	−32 51	243.16	58.34	6.0– 9.2	.43	2
6	G. 78 *f Lupi*	15 11 8	−29 41	nf	–	4.0– 8.0	.40	1
7	G. 126 *Lupi*	15 36 58	−41 28	354.87	(1.0)	7.0– 8.5	.40	2
8	G. 28 *Scorpii*	16 2 31	−32 21	266.46	6.85	7.1– 7.2	.42	2
9	G. 62 *Ophiuchi*	16 50 36	−19 22	231.75	4.57	6.7– 7.1	.41	2
10	G. 177 *Scorpii*	17 44 8	−30 31	190.56	9.56	7.1– 8.4	.42	2
11	Ll. 33612 (β 639)	18 12 13	−18 40	51.17	16.67	7.2– 7.7	.50	2
12	G. 70 *Sagittarii*	18 22 6	−26 39	182.73	11.80	6.7– 7.7	.50	2
13	G. 36 *Cor. austr.*	18 53 39	−37 13	282.60	11.61	6.7– 7.0	.54	2
14	G. 135 *Sagittarii*	18 57 36	−23 4	307.43	7.46	7.1– 8.4	.53	2

Observatory of St. Petersburg, 1891 *April* 2.

FILAR-MICROMETER OBSERVATIONS OF COMET 1890 IV (ZONA).

MADE WITH THE 8-INCH EQUATORIAL OF THE OBSERVATORY OF YALE UNIVERSITY.

By F. L. CHASE.

1890 New Haven M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log p Δ	
d h m s			m s	′ ″	h m s	° ′ ″		
Nov. 20 14 57 29.5	1	11 , 11	−1 10.82	−3 53.3	5 4 58.53	+31 32 5.2	n9.406	0.164
29 6 56 57.6	2	9 , 9	+0 53.83	−1 38.6	4 13 41.14	+35 9 49.1	9.705	0.537
Dec. 2 9 1 21.7	3	8 , 8	+0 25.37	−4 51.0	3 56 3.30	+35 0 53.3	9.152	0.181
4 10 5 13.1	4	7 , 6	+0 59.34	+3 37.8	3 44 50.18	+34 48 44.9	9.010	0.012
7 9 1 43.7	5	12 , 12	+0 20.20	−5 18.1	3 29 24.75	+34 26 43.6	9.263	0.094
12 8 35 23.6	6	6 , 6	+0 3.55	+4 3.2	3 5 51.79	+33 34 40.5	9.165	0.113
13 8 19 15.2	7	8 , 8	+2 16.00	+1 57.8	3 1 38.11	+33 23 4.0	9.208	0.129
14 7 16 31.6	8	8 , 8	−2 9.24	−1 1.5	2 57 39.11	+33 11 3.8	9.139	0.237
15 7 33 6.7	9	12 , 12	−1 10.48	+2 9.5	2 53 33.68	+32 58 39.3	9.352	0.202

Mean Places for 1890.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	5 6 5.68	+3.67	+31 35 47.8	+11.2	Weisse's Bessel V. 66
2	4 12 43.48	+3.82	+35 11 16.7	+10.7	Bonn VI. 35 845
3	3 55 34.12	+3.81	+35 5 31.6	+12.7	Weisse's Bessel III. 1143
4	3 43 47.10	+3.74	+34 44 53.2	+13.9	Yarnall 1730
5	3 29 0.88	+3.67	+34 31 46.3	+15.4	Bonn VI. 34 690
6	3 5 47.70	+3.51	+33 30 19.8	+17.5	Bonn VI. 33 600
7	2 59 9.41	+3.50	+33 20 11.9	+18.5	Weisse's Bessel. II. 1373
8	2 59 35.64	+3.51	+33 11 21.5	+18.1	" " II. 1381 [+15′37″.1
9	2 52 3.17	+3.44	+32 40 31.1	+18.6	Comp. with W.B. II. 1195 (+2′ 37″.55

FILAR-MICROMETER OBSERVATIONS OF ASTEROIDS (287) *NEPHTHYS* AND (6) *HEBE*.

MADE WITH THE 8-INCH EQUATORIAL OF THE OBSERVATORY OF YALE UNIVERSITY.

By F. L. CHASE.

1891 New Haven M.T.	*	No. Comp.	Planet — * Δα	Planet — * Δδ	Planet's Apparent α	Planet's Apparent δ	log p Δ	
			(287) *Nephthys.*					
d h m s			m s	′ ″				
Jan. 14 8 30 36.5	1	10 , 10	−1 11.79	−3 6.0	6 16 47.83	+13 16 2.2	9.461	0.640
16 8 50 36.6	2	12 , 12	+0 31.47	−1 5.4	6 11 50.71	+13 28 1.9	9.387	0.634
			(6) *Hebe.*					
Jan. 25 11 31 48.0	3	10 , 10	−0 20.88	+2 58.3	10 9 0.05	+12 28 25.0	9.401	0.678
26 10 7 0.4	4	9 , 9	+0 11.01	−3 37.8	10 8 18.80	+12 37 27.1	9.562	0.680
27 11 36 49.5	4	10 , 10	−0 1.57	+6 50.6	10 7 30.23	+12 17 55.5	9.559	0.678
Feb. 1 9 55 25.7	5	20 , 20	+1 11.62	+1 18.0	10 3 29.96	+13 37 33.4	9.540	0.662
2 10 21 45.9	6	11 , 11	−1 19.51	+6 9.1	10 2 37.59	+13 18 1.2	9.183	0.647
4 9 12 43.2	7	12 , 12	+2 21.22	+1 0.7	10 0 55.50	+11 8 21.8	9.580	0.669
8 9 44 59.5	8	16 , 16	+0 34.80	−1 10.4	9 57 17.50	+11 50 12.3	9.429	0.646

Mean Places for 1891.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	6 48 29.15	+0.47	+13 19 7.0	+1.2	Lalande 13340
2	6 44 15.81	+0.46	+13 32 9.2	+1.1	Lalande 13440
3	10 9 20.41	+0.52	+12 25 26.2	—1.5	Weisse's Bessel X 145
4	10 7 34.25	[illegible]	+12 44 6.4	1.5 1.6	Schjellerup 3742-3
5	10 1 44.72	+0.62	+13 33 17.3	—1.9	Weisse's Bessel IX 1279
6	10 2 56.17	+0.63	+13 41 51.0	—1.9	DM. +13 2214 comp'd with *5
7	9 58 33.58	+0.70	+11 7 23.1	—2.1	Schjellerup 3696
8	9 56 41.92	+0.78	+11 51 54.6	—2.3	Schjellerup 3688

OBSERVATIONS OF COMETS,

MADE WITH THE 15-INCH EQUATORIAL OF THE HARVARD COLLEGE OBSERVATORY.

By O. C. WENDELL, Assistant.

[Communicated by Prof. Edward C. Pickering, Director.]

Cambridge M.T.	*	No. Comp.	☌ — * Δα	☌ — * Δδ	☌'s apparent α	☌'s apparent δ	log *p*Δ for α	log *p*Δ for δ
1890				Comet 1889 I.				
June 10ᵈ 11ʰ 36ᵐ 18ˢ	1	4	+0ᵐ 3ˢ.21	+ 6′ 59″.3	17ʰ 50ᵐ 30ˢ.15	— 6° 54′ 23″.4	*n*9.027	0.823
				Comet 1890 II.				
Sept. 8 9 7 17	2	5	+1 31.66	— 2 42.8	13 0 12.13	+33 32 2.6	9.692	0.792
				Comet 1890 III.				
Aug. 1 8 49 23	3	7	—0 22.93	— 2 13.4	10 18 1.33	+33 3 11.0	9.694	0.787
				Comet 1890 VI.				
Sept. 8 8 26 53	4	7	+0 59.09	—10 26.5	15 14 5.32	+13 57 38.9	9.586	0.694
1891				Comet *a* 1891 (Barnard, *Mar. 29*).				
Apr. 1 8 28 19	5	5	—1 30.28	+ 8 10.1	1 8 52.10	+41 48 42.1	9.706	0.820
8 7 46 52	6	6	—0 31.59	+ 8 47.0	1 25 22.86	+34 29 28.0	9.691	0.800
9 7 53 22	7	7	+0 37.34	+ 8 8.4	1 27 20.84	+33 25 32.6	9.676	0.810

Mean Places for 1890.0 and 1891.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	17 50 25.27	+1.67	— 7 1 20.9	—1.8	Lamont (—3° to —9°) Suppl. 2508
2	12 58 40.65	—0.18	+33 34 41.4	+4.0	W. Bessel XII, 1125
3	10 18 24.66	—0.10	+33 5 19.5	+4.9	B.B. VI, 33° 1981
4	15 13 5.62	+0.61	+14 7 59.1	+6.0	W. Bessel XV, 795
5	1 10 21.52	—2.11	+41 40 37.6	—5.3	4 comp. with W. Bessel I, 118
6	1 25 59.17	—1.72	+34 20 46.8	—5.8	W. Bessel I, 518
7	1 26 45.19	—1.69	+33 17 30.2	—6.0	W. Bessel I, 539

ERRATA.

In Vol. X, p. 69 observations of Dec. 26, *for* —5′ 12″.6, *read* —9′ 33″.6.
" " " observations of Dec. 26, *for* +6 18′ 47″.2, *read* +6 14′ 26″.2.
" " " observations of Dec. 27, *for* +2ᵐ 22ˢ.26, *read* +2ᵐ 52ˢ.26.
" " " observations of Dec. 27, *for* 0ʰ 33ᵐ 44ˢ.14, *read* 0ʰ 34ᵐ 14ˢ.14.

OBSERVATIONS OF COMET 1889 V (*BROOKS*),

MADE WITH THE 36-INCH REFRACTOR. AND ON THE EXTENDED VISIBILITY OF THREE SMALL COMETS OF 1889,

By E. E. BARNARD.

I have collected here all the observations of this important comet which I have been able to make with the great telescope since refinding it on Nov. 21, 1890. The comparison-stars have all been reobserved with the micrometer. The star DM. 26° 1837, to which the January comparison-star was referred, has been observed by Prof. SCHAEBERLE with the meridian circle.

The comet was sought for several times after the January observation, but the seeing was always too poor to get even a trace of it.

As the orbit of this comet will be very accurately known through the aid of these last observations, its return will probably be very closely predicted; it should be observable with the 36-inch when its light-ratio is equal to that of 1891 January 12, if it is then favorably placed for observing. It will be seen that the comet was observed here 290 days after it had passed beyond the reach of every other observatory in the world. These observations make the total visibility of the comet extend through 555 days, which therefore exceeds the duration of visibility of the great comet of 1811. It may be interesting to note that within less than five months' time three small comets — 1889 I, 1889 II, 1889 V — were carried here beyond the duration of visibility of anything previously known in the comet line. (See also *A.J.* 225).

Following are the observations with the great telescope.

FILAR-MICROMETER OBSERVATIONS OF COMET 1891 V. (*BROOKS*).

MADE WITH THE 36-INCH EQUATORIAL OF THE LICK OBSERVATORY, BY E. E. BARNARD.

Mt. Hamilton M.T. 1890–91		*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
d	h m s			m s	′ ″	h m s	° ′ ″		
Nov. 21	16 18 48	26	3	−0 1.18	−1 44.1	9 0 31.53	+21 13 1.0	n8.851	0.303
22	16 47 44	26	*2 , 2	+0 3.49	−0 12.2	9 0 39.23	+21 14 32.8	n7.954	0.291
Dec. 20	16 46 26	27	*3 , 5	−0 15.93	+1 31.7	8 54 10.23	+25 25 0.5	9.394	0.332
Jan. 12	10 20 45	28	3*	+0 2.98	. . . .	8 38 1.63	. . . .	n9.545	. .
	10 35 21	28	4	. . . .	+0 19.1	. . . .	+26 12 28.0	. .	0.381
	11 5 16	28	2*	+0 0.74	. . . .	8 37 59.39	. . . .	n9.425	. .
	11 14 59	28	2	. . . .	+0 22.7	. . .	+26 12 31.6	. . .	0.312

* Δα measured direct with micrometer.

Mean Places for 1890.0 and 1891.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority	
	h m s	s	° ′ ″	″		
26	9 0 33.31	(+2.37) (+2.40)	+21 14 55.4	(−10.3) (−10.1)	13ᴹ comp'd with W.B. VIII, 1417,	(+50s.93 (7) (+1′ 7″.2 (8)
27	8 51 22.87	+3.29	+25 23 44.7	−15.9	9ᴹ.7 comp'd with B.B. +25° 2027	(−0 18s.61 (42) (−7′ 29″.6 (6)
28	8 37 58.13	+0.52	+26 12 9.2	− 0.3	12ᴹ comp'd with DM. +26° 1837	(−1 26s.02 (21) (+0′ 42″.4 (7)

Star 28. The place of DM. 26° 1837 has been observed with the meridian circle of the Lick Observatory by Prof. SCHAEBERLE. 1891.0 $\alpha = 8^h\,38^m\,24^s.75$, $\delta = +26°\,41'\,27''.1$. One observation.

From this it appears that the [illegible] of DM. 26° 1837 is [illegible] great.

Mt. Hamilton 1891 April 10.

ON THE TRUE DATE OF THE BATTLE OF PYDNA.

By JOHN N. STOCKWELL.

In my communication of April 2, I have discussed two eclipses of the moon, each of which has been supposed to be the one which was predicted by SULPICIUS GALLUS, and which took place during the night which preceded the decisive battle of Pydna. The agreement of the calculated with the observed eclipse, in either case, was far from being satisfactory; especially when we consider the great confusion which the supposition of either of them being the correct one would imply in the Roman calendar. I have since given the subject further consideration, and have apparently [illegible] perfect success that I am unable to understand why either of the eclipses there considered should ever have been regarded as the correct one. For I find that in the year [illegible] B.C., of ordinary chronology, there was an eclipse of the moon on September 3, which agrees so perfectly with the historical account of the event that it seems impossible to withhold the conclusion that this is really the eclipse to which the historian refers.

According to my computation the eclipse commenced at 11h 58m in the evening of September 2, and ended at 2h 58m on the morning of September 3. The middle of the eclipse was therefore at 1h 28m in the morning, Pydna mean time. The eclipse was very nearly total, having a magnitude of *eleven digits* on the moon's northern limb. This agrees perfectly with PLUTARCH's account in all respects except that of totality; but it was so nearly total that the slight discrepancy in that respect would carry very little weight in the question of its identity. The calendar date of the eclipse, September 3, is the same as the date assigned by LIVY; and hence we may infer that the Roman calendar at that time was practically free from the confusion which afterwards crept into it during the period of the civil wars of Rome. I think we may therefore confidently give, for the true date of the battle of Pydna, September 3, 172 B.C.; which precedes the date usually assigned to that event by four years.

Cleveland, Ohio, 1891 *April* 21.

OBSERVATIONS OF D'ARREST'S COMET, 1890 V,

BY E. E. BARNARD.

The continuous bad weather during the winter here prevented D'ARREST's comet being followed as long as was expected. Dr. GOULD kindly furnished me with a special ephemeris for following it. When, however, a clear sky did occur the comet could not be found with the 12-inch. On Feb. 25, with a good clear sky, it had got beyond the reach of that instrument.

From the diffused nature of this comet it required the lowest powers to condense it, and to give contrast with the sky. During the middle of its visibility I could see it quite easily with the 3¼ finder of the 12-inch, and several times swept it up, without thinking of its presence, with the 4-inch broken tube comet-seeker.

In *A.J.* 228, I have given a history of the search for this comet and of my accidentally finding it on Oct. 6, 1890.

I have inserted in the following list the first three observations, which have already appeared in *A.J.* 227, because there they are given under a heading which is misleading, as it was then supposed to be a new comet.

FILAR-MICROMETER OBSERVATIONS OF D'ARREST'S COMET,

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY, BY E. E. BARNARD.

1890 Mt. Hamilton M.T.		✳	No. Comp.	☄ — ✳		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
	d h m s			m s	′ ″	h m s	° ′ ″		
Oct.	6 9 23 10	1	5*, 6	+0 17.37	—2 7.0	19 13 30.88	—26 7 30.5	9.590	0.837
	7 7 34 19	2	16, 6	+2 15.63	+3 22.9	19 17 15.03	—26 18 51.7	9.322	0.886
	8 6 55 58	3	12, 4	+1 11.20	+2 1.0	19 21 11.48	—26 30 7.6	9.017	0.895
	9 7 2 55	4	16, 7	—0 19.26	—5 32.8	. . . . .	. . . . . .	9.083	0.895
	10 7 8 12	5	18, 9	—0 28.67	—5 55.5	. . . . .	. . . . . .	9.137	0.893
	11 9 19 22	6	3	. . . . .	—2 5.1	. . . . .	. . . . . .	. . .	0.840
	9 29 19	6	16	+0 8.59	. . . . .	. . . . .	. . . . . .	9.606	. . .
	12 9 12 47	7	. . .	+0 15.51	+1 19.2	19 39 29.62	—27 0 31.3	9.572	0.846
	13 7 23 25	8	4*, 6	+0 0.13	+3 5.0	19 40 39.22	—27 2 32.9	9.217	0.842
	14 10 3 16	9	2	. . . . .	—5 36.9	. . . . .	—27 27 16.1	. . .	0.825
	10 12 21	9	8	+1 17.10	. . . . .	19 46 13.69	. . . . . .	9.655	. . .
	15 7 7 15	10	11, 7	—0 20.51	—5 40.3	19 49 53.04	—27 33 19.2	9.111	0.898
	16 7 21 21	11	18, 7	+1 36.21	—7 8.4	19 54 2.24	—27 39 39.0	9.215	0.890
	17 8 5 36	12	18, 6	+0 21.10	+5 10.7	19 58 6.20	—27 45 15.9	9.403	0.881
	30 6 39 11	13	16, 6	—0 28.17	—6 36.6	. . . . .	. . . . . .	8.756	0.902
	31 7 11 35	14	5*, 6	+0 4.62	—5 17.8	20 54 48.18	—27 56 19.9	9.146	0.898
Nov.	2 6 12 17	15	16, 6	+1 39.81	—4 56.9	21 2 32.68	—27 48 48.20	8.845	0.902
	3 7 35 53	16	10, 4	—1 7.53	+5 38.1	21 6 35	—27 45	9.267	0.892
	4 6 41 14	17	12, 6	—1 1.75	+2 18.8	21 10 17.67	—27 38 52.2	8.839	0.901
	7 6 10 31	18	1	. . . . .	—2 1.2	. . . . .	—27 18 14.5	. . .	0.877
	6 51 20	18	12	+0 45.60	. . . . .	21 20 58.89	. . . . . .	8.996	. . .
	9 6 30 46	19	4*, 7	—0 3.06	+5 37.1	. . . . .	. . . . . .	8.663	0.900
	10 6 38 27	20	10, 1	+1 46.19	+2 6.0	. . . . .	. . . . . .	8.785	0.899
	12 7 43 41	21	. . .	—1 19.21	+4 50.8	21 40 22 44	—26 39 36.2	9.326	0.897
	13 8 22 44	22	4	. . . . .	+5 7.3	. . . . .	—26 30 5.1	. . .	0.869
	8 40 1	22	10	+1 31.16	. . . . .	21 44 7.44	. . . . . .	9.504	. . .
	16 7 15 5	23	11, 8	—1 0.44	—1 15.2	. . . . .	. . . . . .	9.170	0.890
	30 6 34 55	24	18, 6	+1 27.45	+6 53.3	22 40 53.88	—23 5 4.0	8.949	0.883
Dec.	9 6 43 23	25	3*, 6	—0 11.96	+0 48.7	23 7 51.82	—20 50 50.6	9.083	0.869
	11 7 5 23	26	10, 2	—3 22.94	—1 58.2	23 13 37.36	—20 45 19.9	9.215	0.866

* Δα measured direct with micrometer.

Mean Places for 1890.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	19 13 11.85	+1.66	−26 5 22.7	−0.8	Gould G.C. 26158
2	19 14 57.74	+1.66	−26 22 13.6	−1.0	" " 26496
3	19 19 55.61	+1.67	−26 32 7.7	−0.9	" " 26615
4	. . . .	+1.68	. . . .	−0.8	9½ magnitude
5	. . . .	+1.68	. . . .	−0.7	9¾ "
6	. . . .	+1.69	. . . .	−0.6	8½ "
7	19 39 12.41	+1.70	−27 1 53.0	−0.5	Gould G.C. 27056
8	19 40 37.39	+1.70	−27 5 37.1	−0.4	" " 27090
9	19 44 51.89	+1.70	−27 21 39.1	−0.4	" " 27179
10	19 50 11.85	+1.70	−27 27 38.6	−0.3	" " 27289
11	19 52 24.30	+1.70	−27 32 30.4	−0.2	" " 27340
12	19 57 43.10	+1.70	−27 50 26.3	−0.3	10M.2 ∗ comp. with Gould G.C. 274[illegible]
13	. . . .	+1.82	. . . .	+1.1	9¾ magnitude
14	20 54 41.71	+1.82	−27 51 3.6	+1.5	9¾M ∗ comp. with Gould G.C. 28961
15	21 0 51.03	+1.84	−27 13 53.0	+1.7	Gould G.C. 28955
16	21 7 40	+1.85	−27 51	+1.8	9¾M approximate
17	21 11 17.56	+1.86	−27 41 13.0	+2.0	Gould G.C. 29203 nf of two
18	21 20 57.01	+1.88	−27 18 16.7	+2.2	Wash. M.C. Zone
19	. . . .	+1.89	. . . .	+2.1	9½ magnitude
20	. . . .	+1.89	. . . .	+2.4	9½ " [illegible] + W.C.Z. 107 no. 50
21	21 42 9.79	+1.89	−26 44 29.7	+2.7	½(Oe. Arg. 21652 + W.T.Z 133 no. 38
22	21 42 31.39	+1.89	−26 35 15.1	+2.8	Oe. Arg. 21656
23	. . . .	+1.90	. . . .	+3.2	
24	22 39 24.50	+1.93	−23 12 2.1	+4.8	W.M. Zones
25	23 8 1.86	+1.92	−20 51 15.0	+5.7	10M comp. with W.C. Zone 152 no. 18
26	23 16 58.38	+1.92	−20 43 27.5	+5.8	W.T. Zones

Star 12 — G.C. 27430. $\Delta\alpha = +1^m\ 49^s.51$ (8), $\Delta\delta = +10'\ 27''.1$ (3). **Star 25** — W.C. Zones 152 no. 18.
Star 14 — G.C. 28961. $\Delta\alpha = +0^m\ 56^s.09$ (8), $\Delta\delta = -\ 4'\ 57''.0$ (3). $\Delta\alpha = -1^m\ 20^s.27$ (10), $\Delta\delta = -6'\ 25''.1$ (2).

Mt. Hamilton, 1891 *April* 12.

THE PARALLAX OF α *TAURI*.

By A. HALL.

In the *Monthly Notices of the Royal Astronomical Society*, *March*, 1891, p. 313, Mr. S. W. Burnham has criticised the reductions of the observations of this star for parallax, assuming that the proper motion of the star of comparison was neglected. Since the relative proper motions of the stars, in angle of position and distance, were found from observations made at distant epochs, this criticism is erroneous, and has no bearing on the determination of parallax. By referring to this *Journal*, no. 156, p. 90, it will be seen that a small error in the proper motions would have no sensible influence on the result.

A similar method of reduction was used by O. Struve.

1891 *April* 29.

REDISCOVERY OF THE PERIODIC COMET 1884 III (*Wolf*).

A telegraphic message, from the Lick Observatory, announces the discovery, by Barnard, of [illegible] position.

May 3.9792 Greenw. M.T. $\alpha = 22^h\ 33^m\ 16^s.6$, $\delta = +15°\ 11'\ 28''$.

Comparison of this position with that given by the ephemeris of Berberich (*A.J.* X, 175) indicates the corrections needed by that ephemeris to be $\Delta\alpha = -32^s.6$, $\Delta\delta = -6'.5$.

For the time of perihelion, the right-ascension would give Sept. 4.23 Berl. M.T., but the declination would give Sept. 7.07. A similar result is afforded by the computations of Thraen, according to which the right-ascension gives Sept. 4.2[illegible] and the declination Sept. 8.15.

The position, as telegraphed, seems therefore not to represent either of these two orbits, within the limits of probable error.

NEW ASTRONOMICAL WORK.

Bestimmung von Parallaxen durch Registrir-Beobachtungen am Meridiankreise, von Prof. Dr. J. C. Kapteyn. Haag (1891), 128 pp. 4to.

This memoir is intended to form a part of the seventh volume of Leiden observations which is not yet published. It contains the record of an attempt to measure the parallaxes of stars by differential meridian transit observations. The observations which constitute the basis of investigation were made during the vacation-time of the author, in order to ascertain and illustrate the capabilities of this method, which differs in important particulars from any which has hitherto been employed for the purpose.

In his parallax-observations Dr. Kapteyn employed the transit-circle of the Leiden Observatory. The observations were made in four periods of nearly maximum parallax in right-ascension: 1885 April and December, 1886 December and 1887 April. They were arranged to determine the parallaxes of fifteen stars, selected from Argelander's well known list of 250 stars having large proper motions (*Bonner Beob.*, Bd. VII). In the arrangement of the observations, as well as in the methods of computation, special precautions are exercised to avoid the effects of systematic errors. The star-images were reduced to approximate equality of brightness through the use of wire screens placed in front of the object-glass.

The results by each comparison-star on each night are fully exhibited in extensive tables. In the final equations, the unknown quantities to be determined are: x, a correction to the assumed difference of R.A. between the principal and comparison-star; π, the maximum differential parallax in R.A.; y, the correction to the assumed differential proper motion. The determinations of the latter quantity afford a check upon the real accuracy of the work. In only two or three cases do these corrections (y) seem to be larger than can be readily attributed to the computed probable errors, and in the exceptional cases there is much uncertainty in the proper motions determinable by the usual method.

After an elaborate discussion of the probable errors, Dr. Kapteyn comes to the conclusion that this probable error of relative R.A. for a parallax star with two comparison-stars is, ±0″.132, while the analogous quantity for the best heliometer work is ±0″.075. One determination by the heliometer is therefore worth 3.11 determinations by the method of differential transits. When, however, the time occupied by the observations is also considered, the degree of accuracy attainable through an equal expenditure of labor of observation by the two methods becomes practically the same. The author also calls attention to the simplicity of the computations in the method of differential transits; and, later, he urges the employment of some of the many available transit-circles in researches of this kind.

The final results for parallax obtained by Professor Kapteyn are appended, π being the differential parallax.

Star	Mag.	p.m.	π	p.e.
		″	″	″
B.B. VII 81 pr.	7.1	1.69	+0.074	±0.027
θ Urs. Maj.	3.0	1.11	+0.052	0.026
B.B. VII 85	8.1	0.79	+0.064	0.022
20 *Leon. min.*	5.8	0.69	+0.062	0.029
B.B. VII 89	7.0	1.43	+0.176	0.024
" " 94	6.3	0.89	+0.101	0.026
" " 95	7.4	0.27	+0.038	0.027
Lal. 20670	7.5	0.30	—0.011	0.029
B.B. VII 104	7.5	4.75	+0.428	0.030
" " 105	8.5	4.40	+0.168	0.027
" " 110 seq.	6.7	0.64	+0.030	0.027
" " 111	8.0	0.67	+0.016	0.032
Groomb. 1830	6.6	7.05	+0.139	0.026
B.B. VII 114	6.6	0.69	—0.038	0.042
" " 119	7.3	0.33	+0.056	0.034

NUMERATION OF RECENTLY FOUND ASTEROIDS.

Mr. Berberich of the *Berliner Jahrbuch* has announced that the asteroid discovered by Charlois Feb. 11 (*A.J.* 167) is identical with no. 208, *Lacrimosa*, the opposition of which, given in the *Jahrbuch* for 1893, had been computed with erroneous elements.

The numbers of the last three announced on p. 167 will consequently remain as there given (See *A.J.* p. 176). Those of March 1 and 5 thus become 306 and 307, respectively; that of March 31 (p. 184), 308; and that of April 6 (p. 191) becomes 309. These changes have been made in the Index to Vol. X.

CONTENTS.

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OBSERVATIONS OF VARIABLES OF THE *ALGOL*-TYPE, 1890-91.

By PAUL S. YENDELL.

The minima detailed below are the results of the continuation of the same line of observation from which the times published by me in Vols. VIII and IX of this *Journal* were deduced.

In spite of the unfavorable weather which has prevailed during the entire year, all the known variables of this type are represented, with the exception of *S Cancri*, of which I have observed no minimum since those published in Vol. IX, and *Y Cygni*, my observations of which star for 1890 have already been published in these pages.

The time made use of is Local Mean Time, which is substantially the same as that of Cambridge, for the purposes of this work.

320. *U Cephei*.

Two minima have been observed.

1890 Oct. 18; seventeen observations, from $6^h\ 50^m$ to $10^h\ 15^m$.
Time of minimum by single curve, $8^h\ 6^m.5$, wt. 4.
Time of minimum by mean curve, $8^h\ 37^m$.
Time of minimum by equal brightness,

	Before	After	Mean
M	h m	h m	h m
8.5	7 30	10 10	8 36.5
8.9	7 19	9 55	8 37.0
9.0	7 25	9 45	8 35.0
9.1	7 30	9 40	8 35.0
9.2	7 40	9 28	8 31.0
Mean of middle times			8 35.7

1890 Oct. 28; eight observations, from $7^h\ 13^m$ to $9^h\ 8^m$.
Time of minimum by single curve, $8^h\ 11^m.8$, wt. 3.
Time of minimum by mean curve, $8^h\ 20^m.0$.
Time of minimum by equal brightness,

	Before	After	Mean
M	h m	h m	h m
9.3	7 51	8 33	8 12
9.4	8 3	8 16	8 9.5
Mean of middle times			8 10.75

1090. *Algol*.

Two minima.

1890 Nov. 20; ten observations, from $6^h\ 8^m$ to $10^h\ 15^m$.
Time of minimum by single curve, $8^h\ 45^m.5$, wt. 4.
Time of minimum by mean curve, $8^h\ 37^m.9$.
Time of minimum by equal brightness,

	Before	After	Mean
M	h m	h m	h m
3.3	7 40	9 50	8 45.0
3.1	8 15	9 31	8 53.0
Mean of middle times			8 49.0

1891 Feb. 14; seven observations, from $6^h\ 22^m$ to $9^h\ 10^m$.
Time of minimum by single curve, $8^h\ 32^m$, wt. 3.
Time of minimum by mean curve, $8^h\ 23^m.5$.

1111. *λ Tauri*.

In view of the fact that this star has been much neglected, a special effort has been made during the past season to secure all available minima; and the attempt has met with a fair degree of success, as will be seen by the appended list of observed minima. No standard light-curve of the star having been published, and my own observations not furnishing sufficient material for the construction of one of a definitive character, no reduction by this process is given.

The minima observed are five, as follows:

1890 Nov. 19; eight observations, from $8^h\ 5^m$ to $11^h\ 40^m$.
Time of minimum by single curve, $10^h\ 1^m$, wt. 4.
Time of minimum by equal brightness,

	Before	After	Mean
M	h m	h m	h m
3.8	8 10	10 45	9 27.5
4.0	9 0	10 28	9 44.0
4.1	9 35	10 16	9 55.5
Mean of middle times			9 42.3

1890 Nov. 23; ten observations, from $6^h\ 35^m$ to $10^h\ 10^m$.
Time of minimum by single curve, $8^h\ 16^m$, wt. 5.
Time of minimum by equal brightness,

	Before	After	Mean
M	h m	h m	h m
4.1	7 25	9 23	8 24.0
4.2	7 57	8 40	8 18.5
4.3	8 8	8 21	8 14.5
Mean of middle times			8 19.0

1890 Nov. 27 ; four observations, from 8^h 11^m to 9^h 0^m.
Time of minimum by single curve, 8^h 36^m, wt. 2.

1891 Feb. 18 ; nine observations, from 7^h 12^m to 10^h 55^m.
Time of minimum by single curve, 9^h 35^m, wt. 5.
Time of minimum by equal brightness,

	Before	After	Mean
M	h m	h m	h m
3.8	8 10	10 50	9 30.0
3.9	8 25	10 35	9 30.0
4.0	8 45	10 21	9 33.0
4.1	9 15	10 4	9 39.5
Mean of middle times			9 33.1

1891 Feb. 22. Twelve observations, from 6^h 40^m to 10^h 45^m.
Time of minimum by single curve, 9^h 40^m, wt. 5.
Time of minimum by equal brightness,

	Before	After	Mean
M	h m	h m	h m
3.8	7 48	10 45	9 16.5
4.0	8 33	10 5	9 19.0
4.1	9 10	9 55	9 32.5
Mean of middle times			9 22.7

2610. *R Canis Majoris.*

One minimum observed.

1891 March 10 ; fourteen observations, from 7^h 15^m to 10^h 25^m.
Time of minimum by single curve, 9^h $23^m.5$, wt. 5.
Time of minimum by equal brightness,

	Before	After	Mean
M	h m	h m	h m
6.7	8 17.5	9 52.5	9 20
6.9	9 10.0	9 35	9 22.5
Mean of middle times			9 21.25

3407. *S Antliae.*

In spite of every effort, I have obtained only three minima of this star during the past season ; several incomplete series were observed, and, in all, I have obtained some sixty available observations, of which use has been made in revising the provisional light-curve published last year. Combining the observations of both years, a curve is obtained, substantially agreeing with the published one in light-range, but differing from it in the fact, that a marked inequality appears in the times occupied by the decrease and increase, the former occupying about 1^h 33^m, and the latter about 2^h 0^m ; in all about three hours and a half. This is fairly in accord with Chandler's published result.

The minima observed are as follows :

1891 Jan. 30 ; six observations, from 10^h 15^m to 11^h 36^m.
Time of minimum by single curve, 10^h 27^m, wt. 4.
Time of minimum by mean curve, 10^h $8^m.5$.

1891 March 10 ; nine observations, from 7^h 50^m to 9^h 30^m.
Time of minimum by single curve, 7^h 58^m, wt. 3.
Time of minimum by mean curve, 7^h $51^m.4$.

1891 April 26 ; six observations, from 8^h 0^m to 9^h 5^m.
Time of minimum by single curve, 8^h 38^m, wt. 3.
Time of minimum by mean curve, 8^h $41^m.2$.

5374. *δ Librae.*

Two minima.

1890 April 20 ; six observations, from 9^h 0^m to 10^h 25^m.
Time of minimum by single curve, 9^h 30^m, wt. 4.
Time of minimum by mean curve, 9^h 24^m.
Time of minimum by equal brightness,

	Before	After	Mean
M	h m	h m	h m
5.8	9 2	9 59	9 30.5

1891 May 2 ; nine observations, from 8^h 20^m to 10^h 45^m.
Time of minimum by single curve, 9^h 42^m, wt. 4.
Time of minimum by mean curve 9^h $21^m.2$.
Time of minimum by equal brightness,

	Before	After	Mean
M	h m	h m	h m
5.9	9 23	10 13	9 48
6.0	9 30	10 0	9 45
Mean of middle times			9 46.5

5484. *U Coronae Borealis.*

Two minima.

1890 April 11 ; nine observations, from 7^h 55^m to 10^h 20^m.
Time of minimum by single curve, 8^h 9^m, wt. 3.
Time of minimum by mean curve, 8^h 12^m.
Time of minimum by equal brightness,

	Before	After	Mean
M	h m	h m	h m
9.0	7 47	8 33	8 10

1890 Aug. 27 ; nine observations, from 8^h 20^m to 10^h 45^m.
Time of minimum by single curve, 9^h 32^m, wt. 4.
Time of minimum by mean curve, 9^h 51^m.
Time of minimum by equal brightness,

	Before	After	Mean
M	h m	h m	h m
8.7	8 58	10 45	9 51.5
8.8	9 6	10 20	9 43.0
8.9	9 25	9 53	9 39.0
Mean of middle times			9 44.5

6189. *U Ophiuchi.*

Three minima observed.

1890 July 5; thirteen observations, from $8^h 55^m$ to $11^h 45^m$.
Time of minimum by single curve, $10^h 56^m$, wt. 3.
Time of minimum by mean curve, $10^h 40^m$.
Time of minimum by equal brightness,

M	Before	After	Mean
6.5	$10^h 16^m$	$11^h 23^m$	$10^h 49^m.5$

1890 July 21; eight observations, from $9^h 15^m$ to $10^h 53^m$.
Time of minimum by single curve, $9^h 45^m$, wt. 4.
Time of minimum by mean curve, $9^h 36^m.7$.
Time of minimum by equal brightness,

M	Before	After	Mean
6.6	$9^h 13^m$	$9^h 56^m$	$9^h 34^m.5$

1890 Sept. 1; eight observations, from $7^h 35^m$ to $9^h 35^m$.
Time of minimum by single curve, $8^h 15^m$, wt. 2.
Time of minimum by mean curve, $8^h 1^m.3$.

The decrease observed before minimum was not enough for a reduction by equal brightness.

Dorchester, Mass., 1891 *May* 16.

RECAPITULATION.

		Single Curve	Mean Curve	Eq. Br
		h m		
320 *U Cephei*	1890 Oct. 18	8 6.5	8 37.0	8 35.7
	28	8 11.8	8 20.0	8 10.75
1090 *Algol*	1890 Nov. 20	8 45.5	8 37.9	8 49.0
	1891 Feb. 14	8 32.0	8 23.5	
1411 *λ Tauri*	1890 Nov 19	10 4.0		9 42.3
	23	8 16.0		8 19.0
	27	8 36.0		
	1891 Feb. 18	9 35.0		9 33.1
	22	9 40.0		9 22.7
2610 *R Can. maj.*	1891 Mar. 10	9 23.5		9 21.25
3407 *Antliae*	1891 Jan. 30	10 27.0	10 8.5	
	Mar. 10	7 58.0	7 54.4	
	Apr. 26	8 38.0	8 44.2	
5374 *δ Librae*	1890 Apr. 20	9 30.0	9 24.0	9 30.5
	1891 May 2	9 42.0	9 21.2	9 46.5
5484 *U Coronae*	1890 Apr. 11	8 9.0	8 12.0	8 10.0
	Aug. 27	9 32.0	9 51.0	9 44.5
6189 *U Ophiuchi*	1890 July 5	10 56.0	10 40.0	10 49.5
	21	9 45.0	9 36.7	9 34.5
	Sept. 1	8 15.0	8 1.3	

FILAR-MICROMETER OBSERVATIONS OF COMET 1890 II (BROOKS).

MADE WITH THE 26-INCH EQUATORIAL OF THE LEANDER MᶜCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA.

[Communicated by the Director.]

1891 Local M.T.	*	No. Comp.	Planet — * Δα	Planet — * Δδ	Planet's Apparent α	Planet's Apparent δ	log pΔ for α	log pΔ for δ	Obs.
d h m s			m s	′ ″	h m s	° ′ ″			
Jan. 13 17 36 5	1	4 . 7	+0 43.64	+3 47.7	12 34 35.66	+31 14 37.3	8.929	0.029	P
14 17 9 10	2	5 . 2	−1 30.60	+3 55.0	12 33 3.01	+31 24 21.1	8.527	9.996	P
17 30 7	3	8 . 3	−1 14.13	+0 00.0	12 33 2.40	+31 24 40.8	8.918	9.978	P
17 43 18	4	8 . 1	−1 51.72	+2 43.3	12 33 0.82	+31 24 38.4	9.054	0.028	P
19 16 45 38	5	3 . 2	−5 58.83	−4 19.4	12 24 37.43	+32 15 30.6	8.660	9.937	P
Feb. 10 15 22 49	6	2 . 2	−6 41.17	−3 26.3	11 37 22.16	+35 28 38.2	9.236	9.725	P
Mar. 13 8 27 1	7	4 . 1	−1 46.65	−1 18.3	. . . . . .	. . . . .	n9.544	0.052	S
9 22 16	8	4 . 4	+3 44.06	−0 33.8	10 23 13.37	+35 58 16.1	n9.365	9.803	P

Mean Places for 1891.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	12 33 52.33	−0.31	+31 10 57.8	−8.2	Leiden Zones, ½[(183,19)+(191,31)]
2	12 34 33.88	−0.27	+31 20 37.3	−8.2	Bonn VI, 2394
3	12 34 16.81	−0.28	+31 24 49.1	−8.3	W.B. 686
4	12 34 52.81	−0.27	+31 22 3.3	−8.2	DM. 2395 comp. with Bonn VI, 2394
5	12 30 36.31	−0.08	+32 19 58.9	−8.9	Leiden Zones, ½[(183,46)+(196,28)]
6	11 44 2.45	+0.88	+35 32 12.5	−8.0	W.B. 828
7	10 25 7.	+1.26	+36 1	+0.2	DM. 2079
8	10 19 28.07	+1.24	+35 58 49.4	+0.5	Glasgow, 2709

S. = ORMOND STONE; P = N. M. PARRISH.

March 13. Nucleus 12 mag.; tail 1′.5 long; position-angle = 230°. Star 4 — B. VI, 2394 = +0 18.93.5 −1 26 [illegible]

LETTER FROM MR. BERBERICH TO THE EDITOR.

I have the honor to send you a continuation of the ephemeris of Wolf's comet. From the first observations of the present apparition (Vienna, Lick). I have deduced a correction of $+3' 0''.0$ for the mean anomaly, which corresponds to an acceleration of 0.34600 days in the perihelion passage. The other elements (*A.J.* 238) have been retained unchanged. Allow me to add the remark that in 1890 the comet was searched for at several observatories, also by Prof. Barnard, with an ephemeris depending on the same elements, but no trace of it has been seen. Now we learn that the correction of that ephemeris could not have exceeded $+10^s$ and $+0'.5$; and we must assume that the comet has been too faint at the opposition of the past year. The computed brightness was about 0.2 of that of May 1, 1891.

A. Berberich.

Berlin, 1891 *May* 6.

CORRECTED EPHEMERIS OF COMET 1891 *(WOLF'S PERIODIC COMET)*.

Berlin Midnight.

	App. α	App. δ	log Δ	log r	Br.
	h m s	° ′			
July 6	1 4 31	+26 30.3	0.1916	0.2305	3.1
7	7 12	26 38.5			
8	9 50	26 46.1			
9	12 29	26 54.1			
10	15 8	27 1.5	0.1800	0.2270	3.3
11	17 48	27 8.6			
12	20 28	27 15.5			
13	23 8	27 22.0			
14	25 49	27 28.3	0.1683	0.2237	3.5
15	28 30	27 34.3			
16	31 11	27 40.0			
17	33 53	27 45.4			
18	36 35	27 50.5	0.1565	0.2206	3.8
19	39 17	27 55.3			
20	41 59	27 59.7			
21	44 41	28 3.8			
22	47 21	28 7.6	0.1446	0.2178	4.1
23	50 6	28 11.0			
24	52 49	28 14.1			
25	55 32	28 16.9			
26	1 58 15	28 19.3	0.1326	0.2152	4.3
27	2 0 58	28 21.3			
28	3 41	28 23.0			
29	6 24	28 24.3			
30	9 7	28 25.2	0.1204	0.2127	4.6
31	11 50	28 25.7			
Aug. 1	14 32	28 25.9			
2	17 15	28 25.7			
3	19 57	28 25.1	0.1081	0.2107	5.0
4	22 39	28 24.1			
5	25 20	28 22.7			
6	28 1	28 20.9			
7	2 30 42	+28 18.6	0.0957	0.2085	5.3

	App. α	App. δ	log Δ	log r	Br.
	h m s	° ′			
Aug. 7	2 30 42	+28 18.6	0.0957	0.2085	5.4
8	33 22	28 15.9			
9	36 2	28 12.8			
10	38 42	28 9.2			
11	41 21	28 5.2	0.0832	0.2068	5.7
12	43 59	28 0.8			
13	46 37	27 55.9			
14	49 14	27 50.5			
15	51 51	27 44.7	0.0707	0.2053	6.0
16	51 27	27 38.4			
17	57 2	27 31.6			
18	2 59 36	27 24.3			
19	3 2 10	27 16.6	0.0581	0.2041	6.4
20	4 43	27 8.4			
21	7 14	26 59.7			
22	9 44	26 50.5			
23	12 14	26 40.9	0.0455	0.2032	6.8
24	14 43	26 30.8			
25	17 10	26 20.1			
26	19 36	26 9.0			
27	22 0	25 57.3	0.0329	0.2026	7.3
28	24 23	25 45.2			
29	26 46	25 32.5			
30	29 7	25 19.3			
31	31 26	25 5.6	0.0204	0.2022	7.7
Sept. 1	33 44	24 51.3			
2	36 0	24 36.6			
3	38 15	24 21.3			
4	40 28	24 5.6	0.0080	0.2022	8.2
5	42 39	23 49.3			
6	44 49	23 32.4			
7	46 57	23 15.0			
8	3 49 2	+22 57.1	9.9957	0.2024	8.6

The brightness of the comet, at the time of rediscovery, has been taken as unity.

REDISCOVERY AND OBSERVATIONS OF WOLF'S PERIODIC COMET (1884 III).

By E. E. BARNARD.

I have made quite an extended search for this comet since last year (an ephemeris having been kindly supplied me by Dr. Berberich for 1890). It remained too faint, however, for the 12-inch until the morning of May 1, when I found it, after a careful search, close to the position assigned by Dr. Berberich (*A.J.* 238).

The comet was extremely faint and small. I estimated it to be about $13\frac{1}{2}^{\text{M}}$. It was 5″ or 10″ in diameter — a very small, indefinite speck of haze.

The morning of May 6 was cloudy, and it is now foggy, which will prevent observations of the comet here, perhaps, for some time.

Following are the observations.

FILAR-MICROMETER OBSERVATIONS OF WOLF'S PERIODIC COMET *b* 1891,

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY, BY E. E. BARNARD.

1891 Mt. Hamilton M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
May 3 15^h 23^m 33^s	1	8 , 4	+0^m 43^s.56	−1′ 6″.2	22^h 33^m 16^s.71	+13° 11′ 27″.3	n9.641	0.656
15 33 51*	1	4	+0 45.20	. . . . .	22 33 18.35	. . . .	n9.632	. . .
15 41 47	1	1	. . . . . .	−0 45.4	. . . .	+13 11 48.1	. . .	0.613
4 15 10 31	2	10 , 6	−1 49.75	−2 8.7	22 35 26.13	+13 25 33.9	n9.650	0.660

* Time uncertain by as much as two minutes.

Mean Places for 1891.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	22^h 32^m 33^s.79	−0^s.64	+13° 12′ 44″.7	−11″.2	Comp. with W.B. XXII 632
2	22 37 16.43	−0.55	+13 27 53.7	−11.1	W.B. XXII 759

Star 1 — W.B. XXII. 632, $\Delta\alpha = +1^{\text{m}}\ 38^{\text{s}}.92\ (4)$, $\Delta\delta = -1'\ 42''.5\ (2)$.

Mt. Hamilton, 1891 *May* 6.

In the note on p. 7, no. 241, the interpolation was inadvertently made as if the ephemeris had been for noon, instead of midnight. The corrections O—C should therefore have been stated as $+31^{\text{s}}.1$ and $+0'.5$; and the time of perihelion passage, by the two coordinates, agrees within a tenth of a day. Its value appears to be 1891 September 3.52 Gr.

Ed.

OBSERVATION OF THE TRANSIT OF *MERCURY* ON MAY 9, 1891,

AT THE OBSERVATORY OF THE STATE UNIVERSITY, COLUMBIA, MO.,

By MILTON UPDEGRAFF.

The observation was made with the $7\frac{1}{2}$-inch equatorial of this observatory, focal length = 10 ft. 7 in., by Merz *und* Mahler, and the time-piece used was a watch which was compared with the sidereal clock of the observatory, immediately before and after the observation. The power of the eyepiece used is 250.

Ten minutes before the predicted time of first contact, clouds rendered the sun's limb invisible. About two or three minutes before the predicted time of second contact, the clouds cleared sufficiently for the planet and sun's limb were plainly visible — the planet being more than half way on the disk when first seen. The Greenwich time of second contact was observed as follows:

11^h 58^m 12^s second contact suspected. (wt. 1).
11 58 33 time of second contact certainly past. (wt. 2).
11 58 26 adopted time (by watch) of second contact.
−28^s.0 watch *IT*.
11 57 58 observed Greenwich M.T. of second contact.

The limb of the sun and the disk of the planet were not

poorly defined, as seen through the clouds, and the observation was embarrassed by the necessity of changing shade-glasses. The uncertainty of the observed time is estimated at 7^s. Immediately after the observation I decided to give the time marked "suspected," weight 1, and that marked "certainly past," weight 2, in deriving the adopted observed time of second contact. The chief uncertainty in the Greenwich time used lies in our longitude, which, however, cannot be wrong by more than one and one-half seconds.

Mr. H. C. WILLIAMS, one of my students, using the two-inch telescope of our altazimuth instrument, and a watch, corrected by comparison with the sidereal clock, observed the second contact at

$11^h\ 57^m\ 48^s$ Greenwich time.

Three minutes afterward, contact with the sun was completely obscured by clouds, and remained so until sunset.

The position of this observatory is $\lambda = 6^h\ 9^m\ 18^s$ from Greenwich, $\varphi = +38°\ 56'\ 50''$.

THE VARIABLE STARS *T* AND *U MONOCEROTIS*, 1891.

By EDWIN F. SAWYER.

T Monocerotis.

Forty-one observations were obtained on this star, extending from 1890 Nov. 3, to 1891 April 25. From these the following epochs of maxima and minima have been deduced, in Boston M.T., using, as usual, the mean light-curve formed from the 1881–83 observations:

Observed Maxima.	d	h	m	Observed Minima.	d	h	m
1890 Nov.	14	4	25	1890 Nov.	5	4	55
Dec.	12	6	25	Dec.	5	16	10
1891 Jan.	8	3	20	Dec.	30	15	10
Feb.	3	20	44	1891 Feb.	21	8	0
Mar.	1	12	38	Mar.	20	13	40
Mar.	29	2	48				
Apr.	25	8	0				

U Monocerotis.

The observations on this star number 36, and extend from 1890 Nov. 14 to 1891 May 3. When charted, these observations permit the determination of the following times of maxima and minima:

		Light
Maximum —	1890 Dec. 27.0	= 11.8
	1891 Feb. 7.5	15.0
	Apr. 4.0	12.3
Minimum —	1890 Dec. 8.0	—1.8
	Jan. 19.0	+4.2
	Mar. 14.0	—0.8
	Apr. 26.5	+2.2

The interval between the 1st and 2d maximum = 42.5 days; and between the 2d and 3d maximum = 56.5 days. The interval between the 1st and 2d minimum = 42 days; and between the 2d and 3d minimum = 43.5 days. The maxima and minima were all very faint. *U* was not observed brighter than 7.0 mag., and was seen as faint as 7.9 mag., the fluctuations being confined between these limits.

Brighton, Mass., 1891 *May* 28.

CONTRIBUTIONS TO THE KNOWLEDGE OF THE INEQUALITIES IN THE PERIODS OF THE VARIABLE STARS,

By S. C. CHANDLER.

V.

8512. *R Aquarii.*

This is one of the few stars to which an asterisk is affixed in the ephemerides of the *Vierteljahrsschrift*; a mark which denotes the exceptional cases in which the elements of the catalogue, *Astron. Journ.* nos. 179–180, and its supplement no. 216, have not been rigorously employed, but that a provisional correction has been applied thereto. It has been thought advisable, therefore, to publish the investigation on which those elements were based, and the occasion has been utilized to introduce some slight corrections in the various coefficients, resulting from a new solution. I think it will be seen that we have abundant reason for confidence in the general correctness of the elements, and in the reality of the periodical term incorporated. The improved elements are,

$$1811 \text{ Dec. } 4.7 + 387^d.05\,E + 39^d.2 \sin(10°\,E + 230°),$$

which are to be substituted for those of the catalogue, namely,

$$1811 \text{ Nov. } 30.6 + 387^d.16\,E + 35^d.0 \sin(10°\,E + 235°).$$

The column O—C′ below gives the comparison of the observed times of maximum with the first two terms of the above expression, and by its side are the values of the sine-term. The comparison of the two, and the final deviations, O—C, will show how satisfactory is the evidence of the periodical fluctuation of the period.

E	Observed Max.	O—C′	Sine-term	O—C	Authority
		d	d	d	
0	1811 Oct. 20	—45.7	—30.0	—15.7	Harding
2	1813 Dec. 8	—39.8	—36.8	— 3.0	"
4	1816 Jan. 8	—52.8	—39.0	—13.8	"
14	1826 Oct. 23	+17.6	+ 6.8	+10.8	Schwerd
15	1827 Nov. 26	+29.5	+13.4	+16.1	"
30	1843 Oct. 1	+11.8	+ 6 8	+ 5 0	Argelander
32	1845 Oct. 25	— 7.3	— 6.8	— 0.5	"
33	1846 Nov. 19	— 4.4	—13.1	+ 9.0	"
38	1852 Jan. 26:	—45.6:	—36.8	— 8.8:	"
41	1858 July 19:	— 1.9:	—30.0	+28.1:	"
45	1859 July 21	—21.9	—25.2	+ 3.3	"
48	1862 Oct. 5	—11.1	— 6.8	— 4.3	"
51	1865 Dec. 28	+ 7.8	+13.1	— 5.6	Schönfeld
52	1867 Jan. 26	+14.7	+19.6	— 4.9	"
60	1875 Aug. 14	+40.3	+36.8	+ 3.5	Schmidt
61	1876 Aug. 23.8	+29.1	+34.0	— 4.9	"
62	1877 Sept. 14	+28.2	+30.0	— 1.8	"
63	1878 Oct. 7:	+29.2:	+25.2	+ 4.0:	Schwab
63	Oct. 5 1	+25.3	+25.2	+ 0.1	Schmidt
64	1879 Oct. 24	+24.1	+19.6	+ 1.5	"
65	1880 Oct. 28.5:	+ 7.6:	+13.4	— 5.8:	"
66	1881 Nov. 13.6	+ 1.6	+ 6.8	— 5.2	"
67	1882 Dec. 2.0	— 2.0	0.0	— 2.0	"
68	1883 Dec. 25:	— 1.1:	— 6.8	+ 5.7:	Sawyer
68	Dec. 21.0	— 5 1	— 6.6	+ 1.7	Chandler
69	1885 Jan. 4	—12.2	—13.6	+ 1.4	Sawyer

With reference to ARGELANDER's epoch 44, it will be seen by reducing the original observations (B.B. VII, 181) that not only is the date very uncertain, — the observations beginning with the day preceding that assigned for the maximum, — but that the star was then nearly a magnitude fainter than its usual brightness at maximum, which may therefore have easily preceded the assigned date by nearly a month, and thus reduce the above deviation from the elements to nearly zero. In the maximum of 1859 the correction on p. 521, B.B. VII, has been made.

The times of the next few computed maxima are as follows:

E 76 1892 May 10
77 1893 June 1
78 1894 June 25

During the last few years the star's proximity to the sun has prevented the determination of maxima, but next year and thereafter observation will be possible during the morning hours, and it is greatly to be hoped that the star will receive attention.

Cambridge, 1891 *June* 1.

NEW ASTRONOMICAL WORK.

Untersuchungen über das System der Cometen 1843 I, 1880 I *und* 1882 II. *II Theil. Der grosse Septembercomet* 1882 II (*Fortsetzung*). *Von* Dr. HEINRICH KREUTZ, Kiel, 1891.

The first part of this memoir has already been noticed (Vol. VIII, 184). In the present portion the author, with the same characteristic thoroughness and critical ability, carries forward the investigation, by examining more intimately the orbits of the separate portions of the nucleus, after the comet's perihelion passage, and the nature of the cause of the division. Starting with the elements II derived in Part I, a comparison is made with all the observations. After determining directly the relative distance of the various nuclear points, the deviations from the assumed elements of all the observations subsequent to perihelion are referred to a system of coordinates based on the line of the nuclei, with the nucleus (2) as origin. Critical identifications having thus been made of the observations which refer to this nucleus, thirty-two normal places are formed; namely (*a*), eight from observations before the division; (*b*) ten from the direct observation of nucleus (2); (*c*) one from the observation of the comet's entry upon the sun's disk, Sept. 17; (*d*) thirteen from observations in which the point measured, in the line of nuclei, is not certain, and for which, therefore, only the coordinate perpendicular to this line can be used. In this way fifty equations of condition are obtained, the differential coefficients being computed by SCHÖNFELD's formulas. The solution gives the definitive elements III of the nucleus (2). Retaining the normals in groups (*a*), (*c*) and (*d*), unchanged, but making the requisite corrections in the group (*b*) to correspond to the position of the nuclear points (3), (4) and (1), the corresponding elements III for those particles are similarly determined. The comparison of these various sets of elements shows that all are practically identical except in the eccentricity, the corresponding values of the periodic times being, in years, 671.3 for (1), 771.8 for (2), 875.0 for (3), and 955.2 for (4). From a discussion of the various results it is concluded that no definite inference can be drawn as to the situation of the center of gravity of the comet in the line of the nuclei, except that it probably lies between (2) and (4).

A new set of elements, IV, is now derived, solely from the observations after perihelion passage. For (2) and (3) this solution is made in two ways, first regarding all the elements as unknown; second, assuming the plane to be that given by the former elements. Since there appears to be no sensible difference in the planes, the solutions for (1) and (4) are conducted only on the second supposition. In all these solutions it appears that all the elements agree, within their probable errors, with the corresponding elements III, and that the satisfaction of the normal places is not essentially better; consequently, that III may be regarded as the definitive elements for the various nuclear points.

For the determination of the orbit before the division, the appropriate observations are discussed in a similar discriminate manner. From the nature of the case the eccentricity is very indeterminate. A general solution, V, gives the periodic time 1497 years, and one, VI, assuming the plane already deduced from all the observations, gives 1245 years, with probable errors of 186 and 141 years, respectively. This uncertainty as to the form of the orbit before perihelion raises the question whether the observations for this period may not be presented by a parabola; but three solutions, VI, VII and VIII, on varying premises, all answer this question in the negative. It may, therefore, be certainly concluded, that the comet entered our system in an elliptical orbit, whose period of revolution was at least 770 years. The superior limit cannot be definitely named, but Dr. KREUTZ is inclined, from sundry considerations, to place it at 1000 years.

The interesting topic is now taken up of the cause of the division of the comet. Treating this as a result of a disturbing force acting gradually, in the direction of the tangent to the orbit, and varying as the square of the velocity of the comet, and inversely as the square of its distance from the sun, it is endeavored to find the numerical value of the constant, U, of such a force, reckoned positive in the direction of the elliptic motion, and hence negative when the force acts in the same sense as a resisting medium. The treatment of U as a seventh unknown, to be found simultaneously with the elements, involves considerable indeterminateness, from the manner in which it is involved with the eccentricity. Determining the elements as functions of U, the values of the latter, which give a minimum sum of the residual-squares, are —0.1457, [illegible], +0.0418 and +0.0766 for the points (1), (2), (3) and (4), respectively. It is further shown that on the purely hypothetical assumption that the center of gravity of the comet lies midway between (2) and (3), values of U will be obtained which accord satisf [illegible]

well with the foregoing. Also, that the differences in the elements are insignificant, except in the eccentricity, and that results practically as satisfactory could be reached assuming this alone to have been affected, and that the disturbance occurred suddenly, at perihelion passage. A most startling inference is that a change of velocity at perihelion of one or two meters at most, from the total velocity of 178052 meters, is sufficient to account for the observed separation.

Dr. Kreutz concludes this part of the subject by presenting the consideration that, if the disturbance be conceived as concentrated at perihelion, it must be regarded as necessarily generated in the comet itself, and not due to any force emanating from the sun; encountering the objection which may be raised to this view by showing that while such a force may operate in any direction, the components in the direction of the radius-vector, and perpendicular to the orbit, would produce insignificant effects, and that it is only required that the tangential component should be sufficient to cause the observed separation.

The final section of the memoir is devoted to a topic suggested by Schönfeld as interesting theoretically; namely, the effect of a flattening of the solar globe on the motion of a body passing so near it. The discussion leads to a negative result.

EDWARD SCHÖNFELD.

With deep grief the Editor announces the death, at Bonn, on May 1, of Professor Schönfeld. His important labors need not be recounted to astronomers; for his works are not only classic in our science, but are indispensable for all who are engaged in the study of stellar astronomy. The preeminent part which he took, together with Krueger, in Argelander's great *Durchmusterung des Nördlichen Himmels*, — his masterly researches concerning variable stars, both in their observation and in the discussion of the results,— and his subsequent extension of the *Durchmusterung* as far as the southern tropic, — would, each of them, have sufficed to secure for his name an eminent and enduring place in the annals of astronomy.

He was born 1828 Dec. 22, at Hildburghausen, in Saxe-Meiningen, and studied at the universities of Marburg and Bonn. At the latter his marked ability and zeal soon drew the attention, and enlisted the interest, of Argelander, whose assistant at the observatory he became in 1853.

Since that time his scientific labors have been familiar to astronomers, with whom his name has been a guarantee for all that is implied by the words excellence and thoroughness. For minute exactness and exhaustive comprehensiveness of research, it would be difficult to find his superior. Punctilious accuracy and completeness are the unfailing characteristics of his works.

After the essential completion, in 1859, of the observations for the *Durchmusterung*, Schönfeld was appointed to the directorship of the Observatory at Mannheim. The instrumental equipment was very inadequate; yet "evil will bless," and it was, in all probability the absence of instruments of a high order, which led him to concentrate his powers and energy upon the study of variable stars. Not merely his numerous discoveries, but his thorough study of the laws which govern the variations, soon placed him in the front rank of investigators in this field; and when, in 1875, he was called to succeed his revered teacher and friend in the Observatory at Bonn, he stood, by common consent, at their head. Meanwhile he had observed with a ring-micrometer the positions of nebulas visible with the equatorial at his observatory; and published a catalogue of 489 of these, prepared with his wonted refinement of method. Notwithstanding the restricted means at his disposal, this might well serve as a model for subsequent ones.

At Bonn, the control of superior instruments entailed new duties; and while the meridian work of the Observatory was going forward in observations of the zone 40° to 50° so actively that at present few, if indeed any, observations remain to be supplied, Schönfeld personally undertook the vast labor of extending the *Durchmusterung* southward, through twenty additional degrees. His previous experience, while making him familiar with the work, enabled him to improve the methods and to extend the limit of magnitude, and the brilliant success, with which his efforts were crowned, needs no mention here.

On the completion of the observations for the *Südliche Durchmusterung*, Schönfeld resumed his work upon variable stars, which had, in fact, never been altogether discontinued. Indeed, within this last year he announced the essential completion of a new series of results concerning *δ Cephei*, which promised ample material for an independent determination of its light-curve. And he added the sadly suggestive remark that he had been engaged upon a collection of his earlier Mannheim observations of this and other variables, in order to insure their preservation in proper form, for the case that he should himself not be able to publish them.

Schönfeld's remarkable abilities were by no means confined to astronomy. An unusual amount of general information was kept always at his command by a singularly retentive memory. In all matters pertaining to the History of Astronomy this was a wonderful repository of names and dates, and a storehouse of interesting and rarely known details.

Last, though not least, his personal character was befitting a man of high scientific attainments and powers. With extreme modesty, kindliness and considerateness for others, were combined true dignity, unimpeachable honor, and a keen sense of responsibility in all that he did or said. His loss, while still in the fullness of his powers, will long be painfully felt by astronomers.

Cambridge, 1891 *May* 16.

CORRIGENDA.

No. 240, p. 187, col. 1, line 30, insert *not*, at beginning of the line.

p. 188, col. 1, line 15, *for* January 29, *put* December 29.

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EPHEMERIS OF WOLF'S PERIODIC COMET.

By WILLIAM BELLAMY.

Mr. BERBERICH's elements, which were published in no. 238 of the *Journal*, accord very closely with the position observed by BARNARD at rediscovery. The observation of May 3 is best satisfied by a correction of $-0^d.3611$ to the time of perihelion passage, with an outstanding error (in δ) O—C of $-8''.3$. The observation of May 4 is best satisfied by a correction of $-0^d.3685$ with error in δ of $-2''.3$. There is a discordance between these two observations of about 12″ in α and $6\frac{1}{2}''$ in δ. To retain the plane of the elements, and exactly satisfy the mean of the two positions, or even the last one, would require a greater change in the radius-vector than seemed warranted. Neither did I think the date sufficient to determine a probable correction to the plane of the orbit.

I have reduced the major axis to correspond with the shortening of the period, and reduced the eccentricity so as to keep the perihelion distance as before, retaining the plane of the orbit and the line of apsides. These give the following elements, and as it is probable that they will give the comet's place very closely during the whole time of its present visibility, I have computed a careful ephemeris, in the hope it may be found useful for the comparison of observations and the formation of normal places in the computation of a definitive orbit.

ELEMENTS.

$$\left.\begin{aligned}\omega &= 172^\circ\ 49'\ 16''.7\\ \Omega &= 206\ \ \ 22\ \ \ 26\ .3\\ i &= \ \ 25\ \ \ 11\ \ \ 37\ .4\end{aligned}\right\}\text{Mean Eq., 1891.0}$$

$$\begin{aligned}\varphi &= 33^\circ\ 51'\ 16''.56\\ \mu &= 520''.3125\\ \log a &= 0.5558349\\ T &= 1891\ \text{Sept. } 3.45743\ \text{Gr. M.T.}\end{aligned}$$

EQUATORIAL COORDINATES.

$$\begin{aligned}x &= [9.9920630]\,r\sin(v+106^\circ\ 58'\ 36''.90)\\ y &= [9.9999804]\,r\sin(v+\ \ 16\ \ \ 52\ \ \ 19\ .52)\\ z &= [9.2780361]\,r\sin(v+101\ \ \ \ 3\ \ \ 31\ .85)\end{aligned}$$

EPHEMERIS.

Gr. M.T. 1891	App. α h m s	App. δ ° ′ ″	log Δ
May 2.5	22 30 7.63	+12 50 58.6	0.36169
3.5	32 17.00	13 5 4.4	
4.5	34 26.69	13 19 11.0	
5.5	36 36.71	13 33 19.2	
6.5	38 47.05	13 47 28.6	0.35220
7.5	40 57.72	14 1 39.1	
8.5	43 8.72	14 15 50.5	
9.5	45 20.08	14 30 2.4	
10.5	47 31.78	14 44 11.5	0.34257
11.5	49 43.83	14 58 26.8	
12.5	51 56.24	15 12 39.0	
13.5	54 9.02	15 26 51.0	
14.5	56 22.17	15 41 2.7	0.33281
15.5	22 58 35.70	15 55 14.0	
16.5	23 0 49.61	16 9 24.6	
17.5	3 3.91	16 23 34.4	
18.5	5 18.59	16 37 43.1	0.32291
19.5	7 33.65	16 51 50.6	
20.5	9 49.09	17 5 56.6	
21.5	12 4.94	17 20 1.0	
22.4	14 21.20	17 34 3.6	0.31289
23.5	16 37.88	17 48 4.3	
24.5	18 55.00	18 2 2.8	
25.5	21 12.56	18 15 59.0	
26.5	23 30.58	18 29 52.7	0.30274
27.5	25 49.06	18 43 43.7	
28.5	28 8.00	18 57 31.7	
29.5	30 27.44	19 11 16.5	
30.5	32 47.28	19 24 57.9	0.29247
31.5	35 7.64	19 38 35.6	
June 1.5	37 28.44	19 52 9.4	
2.5	39 49.67	20 5 39.4	
3.5	42 11.40	20 19 4.3	0.28207
4.5	44 33.59	20 32 24.8	
5.5	46 56.26	20 45 40.1	
6.5	49 19.44	20 58 50.9	
7.5	23 51 43.03	+21 11 55.9	0.27154

Gr. M.T.	App. α	App. δ	log Δ	Gr. M.T.	App. α	App. δ	log Δ
	h m s	° ′ ″			h m s	° ′ ″	
June 7.5	23 51 13.03	+21 11 55.9	0.27151	July 24.5	1 52 59.01	+28 13 56.7	
8.5	54 7.13	21 24 55.1		25.5	55 41.89	28 16 42.0	0.13556
9.5	56 31.72	21 37 48.3		26.5	1 58 24.82	28 19 6.1	
10.5	23 58 56.80	21 50 35.2		27.5	2 1 7.77	28 21 8.7	
11.5	0 1 22.36	22 3 15.5	0.26089	28.5	3 50.72	28 22 49.4	
12.5	3 48.41	22 15 48.9		29.5	6 33.63	28 24 7.9	0.12342
13.5	6 14.95	22 28 15.1		30.5	9 16.46	28 25 3.8	
14.5	8 41.99	22 40 33.9		31.5	11 59.19	28 25 36.8	
15.5	11 9.53	22 52 45.0	0.25012	Aug. 1.5	14 41.78	28 25 46.5	
16.5	13 37.57	23 2 48.1		2.5	17 24.18	28 25 32.7	0.11116
17.5	16 6.13	23 16 13.0		3.5	20 6.36	28 24 54.8	
18.5	18 35.20	23 28 29.5		4.5	22 48.28	28 23 52.4	
19.5	21 4.80	23 40 7.3	0.23923	5.5	25 29.92	28 22 25.2	
20.5	23 34.92	23 51 36.1		6.5	28 11.23	28 20 33.1	0.09880
21.5	26 5.56	24 2 55.5		7.5	30 52.18	28 18 15.4	
22.5	28 36.71	24 14 5.3		8.5	33 32.71	28 15 31.9	
23.5	31 8.37	24 25 5.2	0.22822	9.5	36 12.76	28 12 22.4	
24.5	33 40.53	24 35 55.0		10.5	38 52.31	28 8 46.7	0.08635
25.5	36 13.20	24 46 31.3		11.5	41 31.34	28 4 44.4	
26.5	38 46.36	24 57 2.8		12.5	44 9.83	28 0 15.2	
27.5	41 20.02	25 7 20.1	0.21708	13.5	46 47.74	27 55 18.9	
28.5	43 54.17	25 17 26.0		14.5	49 25.01	27 49 55.3	0.07382
29.5	46 28.80	25 27 20.2		15.5	52 1.60	27 44 4.1	
30.5	49 3.91	25 37 2.3		16.5	54 37.47	27 37 45.0	
July 1.5	51 39.48	25 46 31.9	0.20581	17.5	57 12.57	27 30 57.8	
2.5	54 15.54	25 55 48.6		18.5	2 59 46.85	27 23 42.2	0.06125
3.5	56 51.98	26 4 52.2		19.5	3 2 20.27	27 15 58.0	
4.5	0 59 28.88	26 13 42.2		20.5	4 52.78	27 7 45.0	
5.5	1 2 6.20	26 22 18.3	0.19442	21.5	7 24.34	26 59 2.9	
6.5	4 43.93	26 30 40.1		22.5	9 54.89	26 49 5.4	0.04865
7.5	7 22.05	26 38 47.2		23.5	12 24.41	26 40 10.4	
8.5	10 0.56	26 46 39.3		24.5	14 52.82	26 29 59.7	
9.5	12 39.45	26 54 16.1	0.18289	25.5	17 20.08	26 19 19.1	
10.5	15 18.72	27 1 37.3		26.5	19 46.12	26 8 8.4	0.03605
11.5	17 58.34	27 8 42.5		27.5	22 10.89	25 56 27.6	
12.5	20 38.31	27 15 31.3		28.5	24 34.34	25 44 16.5	
13.5	23 18.60	27 22 3.4	0.17124	29.5	26 56.43	25 31 34.6	
14.5	25 59.21	27 28 18.4		30.5	29 17.08	25 18 21.6	0.02349
15.5	28 40.13	27 34 16.0		31.5	31 36.23	25 4 37.3	
16.5	31 21.34	27 39 55.8		Sept. 1.5	33 53.86	24 50 21.6	
17.5	34 2.81	27 45 17.6	0.15947	2.5	36 9.92	24 35 34.7	
18.5	36 44.53	27 50 21.0		3.5	38 24.36	24 20 16.7	0.01102
19.5	39 26.48	27 55 5.7		4.5	40 37.13	24 4 27.5	
20.5	42 8.65	27 59 31.3		5.5	42 48.19	23 48 7.3	
21.5	44 51.01	28 3 37.6	0.14758	6.5	44 57.49	23 31 16.1	
22.5	47 33.54	28 7 24.2		7.5	3 47 4.97	+23 13 53.9	9.99871
23.5	1 50 16.22	+28 10 50.7					

NEW ASTEROID.

An asteroid of the thirteenth magnitude was discovered by Charlois, at Nice, June 11, in the position.

1891 June 11.5633 Greenw. M.T., $\alpha = 17^h\ 22^m\ 53^s.1$, $\delta = -23^\circ\ 10'\ 54''$.

Daily motion in right-ascension —56ˢ, in declination 0′.

OBSERVATIONS OF THE ZODIACAL COUNTERGLOW, OR *GEGENSCHEIN*, MADE AT MT. HAMILTON DURING THE YEARS 1888, 1889, 1890, 1891.

By E. E. BARNARD.

In a paper in the *Astronomical Journal*, Vol. VII, p. 186, I have given an account of the zodiacal counterglow, or *Gegenschein*, with sixteen observations of its position, made at Nashville, Tenn., during the years 1883 to 1887 inclusive.

During the years 1888 to 1891, I have obtained sixteen more observations of its position here at Mt. Hamilton. These last are made under better conditions for observation than were those at Nashville. They confirm the previous observations, and settle quite definitely several important facts.

The changes of form, to which I called attention in the paper above referred to, have been amply confirmed. When first seen in the fall, the *Gegenschein* is large and roundish, and does not seem to be connected with any zodiacal bands. Later, after passing 0^h, it becomes very much elongated along the ecliptic, and is connected with the evening and morning zodiacal light by a narrow zodiacal band. It cannot be seen in June and December, because in those months it is crossing the milky-way. When the background of the sky is favorable, however, it is always visible here.

The *Gegenschein*, though always close to the ecliptic, does not lie in it. The observations prove conclusively that it is nearly always seen in a north latitude. It is possible that this may in part be due to atmospheric absorption, though the observations, extending through 40° of zenith-distance, do not give much weight to this suggestion. It is a question, however, that can only be settled by corresponding observations in the southern hemisphere. Parallax would tend to give it a southern latitude.

The observations also prove that the *Gegenschein* is not always exactly 180° from the sun. There is certainly an oscillation of a degree or more from $\odot + 180°$. That is, $\odot - \lambda$ is not a constant quantity, there being a tendency to a less longitude than $\odot + 180°$.

In some cases the observations have been made three or four hours from the meridian, but they do not seem to show any positive parallax — on the assumption that $\odot - \lambda$ is a constant quantity.

I have suggested in my previous paper (*A.J.* VII, 186), that the phenomenon may be due to some abnormal condition of refraction by our own atmosphere. There are a number of objections to this theory, but it might be well to consider it further.

In his *Mechanical Theory of the Corona*, as published in the Lick Observatory Report of the eclipse of 1889 Dec. 21–22, Professor SCHAEBERLE has pointed out that a phenomenon similar to the observed *Gegenschein* will be produced by a system of nearly radial luminous lines having the sun as a center of divergence. The center of the *Gegenschein* is one vanishing point of such a system of lines, while the center of the solar corona is the nearly diametrically opposite vanishing point of a similar system of lines.

These lines, he claims, produce, in perspective, all the well known coronal forms. Perhaps sufficient observations have now accumulated to test one or the other of these theories.

I have referred to the zodiacal band. This is very often present, crossing the entire heavens. It is usually from 3 to 4° wide, and lies along the ecliptic. In the fall it is specially distinct, when it passes between the *Pleiades* and the *Hyades*. Farther east of this, its junction with the milky-way is very marked.

Below are the observations of the *Gegenschein* made here. These I have also converted into longitude and latitude for comparison.

They have been made with the greatest care, and should have great weight in any discussion of the phenomenon.

I have retained the form of the table given in *A.J.* VII, 186, and have added a column of hour-angles, + indicating a west hour-angle.

It would have been better to have given the differences $\lambda - \odot$, instead of $\odot - \lambda$, but it appeared best to conform to the previous tabulation to prevent confusion.

Positions of the *Gegenschein*.

	Date		α	δ	λ	β	$\odot - \lambda$	h
	G.M.T.		h m					
1888	Apr.	4.83	13 0	— 3.4	195.1	+2.8	180.8	0.0
	Aug.	28.75	22 33	— 8.2	336.8	+0.8	179.6	—1.6
	Sept.	1.83	22 17	— 6.2	340.8	+1.6	179.5	+0.2
	Oct.	30.79	2 11	+13.5	35.7	+0.1	182.5	—1.1
	Nov.	2.71	2 11	+17.4	36.4	+3.9	184.8	3.6
1889	Jan.	23.67	8 26	+20.4	123.9	+1.1	180.5	1.2
	Jan.	27.80	8 46	+19.4	128.7	+2.1	179.9	+0.5
	Feb.	7.76	9 36	+17.0	140.7	+2.5	179.1	+3.3
	Feb.	25.79	10 17	+13.5	155.4	+2.2	182.7	—0.9
	Apr.	29.83	14 29	—14.6	219.6	+0.1	180.6	0.0
	July	21.80	20 11	—19.5	300.7	+0.6	179.0	—0.5
	Oct.	23.83	1 53	+11.9	30.5	+0.2	180.7	+0.5
1890	Mar.	11.71	11 29	+ 3.7	171.4	—0.3	180.2	—2.3
1891	Apr.	3.77	12 18	— 1.8	198.1	—0.3	176.2	—1.5
	Apr.	30.72	14 25	—12.3	218.0	+2.0	182.6	—2.6
	May	2.75	14 40	—13.1	221.9	+2.4	180.7	—2.0
						+1.3	180.6	

The indiscriminate mean of these positions of the *Gegenschein* give

$$\odot - \lambda = 180°.6, \qquad \beta = +1°.3.$$

The previous observations (*A.J.*, Vol. VII, p. 186) gave

$$\odot - \lambda = 180°.6, \qquad \beta = +0°.3.$$

The following notes may be of value in interpreting the phenomenon.

1888 *April* 4. A very diffused *Gegenschein* of no definite form. The presence of *Mars* makes it difficult to be more than certain of its existence. [Observation made while on a visit here before the opening of the observatory.]

1888 *August* 28. For the past few nights I have looked for it; have also looked for it quite a number of times since April, but have not been able to see it until to-night. It is visible now, but faint, and seems to be very diffuse, with a greater depth of brightness at the point located. It is about 20° in diameter. There is no sign of zodiacal bands.

1888 *September* 1. It is dense to the eye, but very ill defined. Roundish, vgbM. At 11^h there is a faint, but distinct zodiacal band, extending from the east to the *Gegenschein*. It is 4° broad, and its center passes 2½° south of the center of the *Pleiades*.

1888 *October* 30. It is pretty distinct, 10° broad by 15° long, extended along the ecliptic. A distinct zodiacal band connects it with the east and west zodiacal light. The band is most distinct to the east. It passes between the *Pleiades* and the *Hyades*, and is about 3° or 4° broad. It is not so distinct as the *Gegenschein*, which though hazy, is quite noticeable.

1888 *November* 2. The *Gegenschein* is elliptical east and west; axes 2 × 3; 10° × 15°.

1889 *January* 23. Diffused and elongated, 8° or 10° wide by 12° or 15° long. The presence of *Saturn* and *Praesepe* make it difficult to locate.

1889 *January* 27. Rather dim. Its form cannot be made out, because of *Saturn* and the bright stars.

1889 *February* 7. Roundish, very hazy and not conspicuous. A zodiacal band from the east horizon reaches to it. Probably slightly extended along the ecliptic.

1889 *February* 26. A zodiacal band from the east horizon joins the *Gegenschein*, and passes 3½° north of *Spica*. It is 4° wide. There is no band from the west of the *Gegenschein*.

1889 *February* 27. A fairly strong *Gegenschein* just east of the *Sickle*. Too indefinite to locate on account of the bright stars.

1889 *April* 29. Very large. Much elongated, 1 × 2 east and west. Its length is twice the distance from α to β *Librae* (= 18°). Very hazy and ill-defined.

1889 *July* 21. Round: 7° or 8° in diameter.

1889 *October* 23. Pretty strong *Gegenschein*. Pretty extended v.v., gradually brighter in the middle. First-class position.

1890 *March* 11. Very hazy and diffused. Roundish, quite noticeable, 6° or 8° in diameter.

1891 *April* 3. Large, very difficult to locate, 15° in diameter. Somewhat extended along the ecliptic. An exceedingly hazy zodiacal band, extending from it east and west.

1891 *April* 30. Diffused and hazy. Much elongated. Fair observation.

1891 *May* 2. Very hazy, 10° or 15° in diameter. A distinct zodiacal band passes from the *Gegenschein* to the zodiacal light in the west, which also extends to the *Scorpion* in the east. This band, which passes close to *Saturn*, is 4° or 5° wide.

I hope that some southern observer may be induced to take up observations of this remarkable phenomenon, as it is of the highest importance that the northern latitude of the object may be confirmed.

Mt. Hamilton, 1891 *June* 17.

THE SOLAR PARALLAX AND THE MASS OF THE EARTH,

BY A. HALL.

In 1872 LeVerrier presented to the *French Academy of Sciences* an interesting article on the masses of the planets and the parallax of the sun (*Comptes Rendus*, Tome 75, p. 165). He concluded from his investigations that the time had actually arrived when the mass of the earth to be used in the calculations of celestial mechanics should be derived directly from the motions of the planets, and no longer determined from the solar parallax. Inversely he concludes that the solar parallax should be determined in the same way if we could be sure of having taken into account the actions of all the celestial bodies. But LeVerrier had some doubt on this point, and advised that the velocity of light should be determined again, and also the constant of aberration. Finally, he thought that the transits of *Venus*, to be of much value, should be observed in such a way as to give the solar parallax to 0″.01. The solar parallax which LeVerrier deduced from the mass of the earth, which he found from its action on the planets, is

$$\pi = 8''.866.$$

His formula is

$$\pi = 608''.79 \,.\, \sqrt[3]{m}$$

where m is the mass of the earth. The author gives no values of the quantities he assumed in computing the coefficient, and I have never been able to quite verify it. The formula itself follows from Kepler's third law, combined with the expression for the attraction at the earth's surface. These give the equations,

$$a\,n^2 = 1 + m$$

$$g = \frac{m}{r^2}$$

in which the mass of the sun is taken as the unit of mass. g is the attraction of the earth, and r its radius at the point attracted. In these equations the values of m are really different. In the first equation m includes the mass of the moon; but in the last it denotes the mass of the earth alone: and since in the result the m of the first equation may be neglected with respect to unity, it is the mass of the earth only that is finally used. The potential of the earth's attraction contains in its second term the factor $\sin^2\varphi - \frac{1}{3}$; so that, if we take a point in latitude $\sin\varphi = \sqrt{\frac{1}{3}}$, the attraction of the earth is very nearly like that of a sphere. I have recently repeated my calculation of LeVerrier's formula with various values of the constants depending on the figure of the earth, including those found by Prof. Harkness, and find the following results:

$\pi = 609''.49\,.\,\sqrt[3]{m}\,.$ Bessel

$\pi = 609''.52\,.\,\sqrt[3]{m}\,.$ Clarke

$\pi = 609''.51\,.\,\sqrt[3]{m}\,.$ Harkness

It will be seen that the coefficient varies but little with the different figures of the earth, and it is probable, I think, that there is a small numerical error in the coefficient of LeVerrier. It will be noticed that an error in the mass of the earth has a diminished influence on the parallax, since the logarithm of the mass is divided by 3.

It is doubtful, I think, whether the time has come when the mass of the earth can be determined with sufficient accuracy from perturbations so that LeVerrier's formula can be used to give the solar parallax. But it would be interesting to have the opinion of astronomers who are engaged on the theories of *Venus* and *Mars*.

1891 *June* 20.

OBSERVATIONS OF *T* AND *U MONOCEROTIS*, 1890–91.

By PAUL S. YENDELL.

T Monocerotis.

From 1890 Oct. 13 to 1891 April 26, I obtained fifty-eight observations of this variable. From the single curve plotted from these, seven maxima and two minima are deduced, as follows:

Maxima	w	Minima	w
1890 Nov. 13.4	3	1890 Dec. 3.4	3
Dec. 13.25	3	31.1	1
1891 Jan. 8.6	4		
Feb. 6.5	4		
Mar. 3.0	4		
30.4	4		
Apr. 25.4	4		

U Monocerotis.

Thirty-four observations of *U Monocerotis*, from 1890 Dec. 9 to 1891 April 13, show three rather indefinitely marked maxima, and two more definitely indicated minima. The star has been very faint during the whole season. The observed times, with the estimated magnitudes, are as follows:

Maxima	w	Mag.	Minima	w	Mag.
1891 Jan. 5.5	2	7.3	1890 Nov. 12.0	3	8.0
Feb. 7.0	2	7.0	1891 Mar. 7.5	1	7.5
Apr. 1.0	2	7.0			

Dorchester, Mass., 1891 *June* 6.

NOTES ON THE DOUBLE STARS OF THE *URANOMETRIA ARGENTINA.*

By S. W. BURNHAM.

Referring to the measures by Prof. Glasenapp of some of the stars noted as double in the *Uranometria Argentina*, given in no. 241 of the *Astronomical Journal*, I have made some notes relating to previous observations of these stars which may be of interest in connection with the recent measures. They refer to the stars within —31° decl.

1. This pair was discovered by Howe at Cincinnati in 1875, and will be found in no. 1 of the publications of the Cincinnati Observatory. The distance and angle were only estimated.

2. This star, which was noted as single by Glasenapp on three nights, is certainly not double. I have examined it once with the 12-inch when the conditions were favorable, and the star was absolutely round, and later with the 36-inch with the same result. A distance of 0".2 would have been noticed. There are no faint stars within reasonable limits.

4. My measures in 1889 of both companions will be found in *A.N.* 2957. The two sets of measures are in close agreement.

6. This star was suspected by Glasenapp to be a close pair on one occasion. With the 12-inch refractor it is perfectly round and without a trace of any second star.

7. This was discovered by Howe in 1876 at the Cincinnati Observatory. Distance and angle estimated.

9. This is a very old pair (= Sh. 240), of which there are many measures, commencing with the observations of South and Herschel in 1823. These observers made the distance about 1" more than it is now, but the later measures do not show any substantial change. My measures in 1880 are almost exactly identical with those of Glasenapp.

10. This pair was discovered by Stone in 1877 at Cincinnati. The measures at that place gave

1877.5	189°.8	10".06	3

11. This is also one of the old pairs (Sh. 261). My discovery in this connection (β639) is not the 16″ pair noted by GOULD, and measured by GLASENAPP, but is the duplicity of the principal star of this wide pair. That component was found with the Chicago 18½-inch to be a very close double, and it may be in rapid motion. The following are all the measures: —

	°	″		
1878.66	155.3	0.57	β.	2 *n*
1883.42	137.9	0.35	Sp.	2 *n*

The measures of the wide pair are not very accordant, but on the whole indicate no material change.

	°	″		
1823.15	52.6	16.42	Sh.	1 *n*
1862.72	51.5	16.83	Hl.	1 *n*
1876.6	52.1	17.49	Cin.	1 *n*
1878.66	51.7	17.30	β	2 *n*
1883.29	51.3	17.15	Sp.	3 *n*

The smaller component of the wide pair has a minute attendant about 4″ distant, which I noted with the Washington refractor in 1871. This companion has not been measured.

11. This was discovered by HERSCHEL I. It was described as belonging to Class II, but not measured. There is an error of 10′ in the declination as given by HERSCHEL II. It is noted "duplex" in *Oe. Argel.* The only measures are by the Harvard observers in 1863, and by the Cincinnati observers in 1877. There is no evidence of any change.

All of the stars noted as double in the *Uranometria Argentina*, which are within 31° of the equator, are to be found in some of the various double star-catalogues, with the exception of the ten stars noted below. Two of these are referred to in the preceding notes to the stars observed by GLASENAPP as nos. 2 and 6 of that list.

Lick Observatory, 1891 *June* 1.

No.	*U.A.*	R.A.	Decl.	
		h m	° ′	
1	*Ceti* 161	1 26	−24 17	Dup. 7 . . 8½
2	*Puppis* 128	7 33	−25 5	Dup. 5½ . . 10
3	*Hydrae* 271	11 3	−27 21	Dup. 6 . . 10
4	*Hydrae* 370	11 5	−26 40	Dup. 5.5
5	*Hydrae* 385	11 40	−25 31	Dup. 5¾ . . 7¼
6	*Hydrae* 387	11 13	−27 26	Dup. 4.8 . .
7	*Librae* 56	15 6	−21 50	Dup. 6.8 . . 8
8	*Lupus* 78	15 10	−29 11	Dup. 4.7 . .
9	*Serpens* 70*b*	18 19	+ 7 0	Dup. 7 . . 9¼
10	*Aquarii* 211	23 3	−21 51	Dup. 3.7 . . 10

I have examined all but three of these stars, and have found them all single. The following are notes of the observations: —

3. No near star; good definition. The nearest in the field is a 10–11$^{\text{M}}$ star, 88″ distant, in the direction of 195°. Of course this is too far off to be referred to in the meridian observations.
4. This is No. 2 of the stars referred to in the preceding notes.
5. Single; fine seeing. The nearest star, 9–10$^{\text{M}}$, is distant 62″ in the direction of 322°. The description in *U.A.* applies fairly well to Sh. 184, which is 2$^{\text{m}}$ *p*, and 35′ *n*, but that is noted as double in the proper place.
6. No companion of any kind, and large star round with all powers.
7. Appears perfectly round, and no star near enough to be worth noticing.
8. This is No. 6 of the preceding notes.
9. Absolutely round with the 36-inch. Fine seeing.

It will be well to examine the remaining stars, Nos. 1, 2 and 10, but it is not probable that double star observers have overlooked among the bright stars anything which would be noticed with meridian instruments.

TRANSIT OF *MERCURY* 1891 MAY 9.

REPORT OF THE OBSERVATIONS MADE AT VANDERBILT UNIVERSITY,

BY CHARLES L. THORNBURG.

The observations were made with the six-inch refractor belonging to this observatory; focal length eight feet; magnifying power used, 200; manufacturers, T. Cooke & Sons, York, England. I used the filar position-micrometer, and set the transit thread at that part of the sun's disc where the contact would occur. The day here was beautifully clear from sunrise until sunset. The image of the sun's disc was sharp and distinct until about half an hour before the time for the first contact, when it became unsteady, and gradually grew worse, so that the contacts were observed under only moderately fair circumstances. Time was recorded on a chronograph connected with the sidereal clock, and subsequently corrected for clock-error, and reduced to Greenwich mean time. There were noted at this time two groups of sunspots, and one single spot. Of the two groups, one was north and the other south of the sun's equator; but both were about half way across the disc. The northern group was composed of small spots, while the southern one had a fine large spot, with several smaller ones north of it. The single spot was north of the equator, and near the eastern limb. About a minute before the predicted time of beginning I began to look steadily for the contact, and on perceiving what I suspected to be the touch, immediately pressed the button. A few seconds more proved this record to be correct. During the time between the first and second contacts, frequent examinations were made of the appearance of the planet and disc, but nothing striking was observed, save the gradual increase in the black circular segment, eaten from the sun's bright disc.

Near the time of second contact, I rested my eyes for a

moment, and then began to look steadily for the first silver line around the black disc. This was difficult to determine, owing to the unsteadiness of the image, but when sure of the contact I made the record. The following, expressed in Greenwich mean time, are the observed times of the contacts:

I External contact at ingress.	11 53 19.2
II Internal contact at ingress.	11 57 43.4

The observatory's position is $\varphi = +36^\circ\ 8'\ 51''.43$
$\lambda = +5\ 17\ 12.2$

A TABLE OF THE SUN'S LATITUDE,

BY WILLIAM BELLAMY.

The *American Ephemeris* gives the sun's latitude referred to the ecliptic of date. It is more frequently wanted referred to the ecliptic of Jan. 0. The following table gives the reduction from one to the other. The dates may be taken = Greenwich time without correction, without involving an error of more than 0″.01 during the next fifty years. Or, if we take for any year the Greenwich time when ⊙ = M, and subtract from it Sept. 16.40, the remainder will be a correction to apply to all the dates of the table to obtain $\Delta\Sigma$ correct to 0″.001 or 0″.002 for the ecliptic of Jan. 0.0 of that year. This supposes, of course, that the data of STRUVE and PETERS are correct. The values used in computing the table are as follows:

Log. eccentricity of Earth's orbit.	8.223 755
Log. change of inclination in 1 day.	7.1167
Earth's perihelion — M.	287° 40′
Earth's mean anomaly Jan. 0.0.	358° 30′

Date	$\Delta\Sigma$	Date	$\Delta\Sigma$	Date	$\Delta\Sigma$	Date	$\Delta\Sigma$
	″		″		″		″
Sept. 18.3	—0.005	May 23.5	—0.175	Sept. 28.8	+0.075	Dec. 4.7	+0.435
22.9	.015	27.9	.185	30.4	.085	8.6	.445
28.1	.025	June 1.6	.195	Oct. 2.0	.095	13.9	.455
Oct. 4.2	.035	7.0	.205	3.6	.105	Jan. 3.3	.455
12.1	.045	13.1	.215	5.2	.115	8.3	.445
26.8	.055	22.5	.225	6.8	.125	12.0	.435
Nov. 8.5	.055	July 14.3	.225	8.3	.135	15.4	.425
24.0	.045	22.5	.215	9.9	.145	17.9	.415
Dec. 3.7	.035	28.1	.205	11.4	.155	20.3	.405
11.8	.025	Aug. 1.5	.195	13.0	.165	22.6	.395
19.5	.015	5.4	.185	14.6	.175	24.6	.385
27.1	—0.005	8.8	.175	16.1	.185	26.6	.375
Jan. 0.0	Epoch	12.0	.165	17.7	.195	28.5	.365
4.1	+0.005	14.9	.155	19.3	.205	30.2	.355
13.2	.015	17.6	.145	20.9	.215	31.9	.345
25.9	.025	20.2	.135	22.5	.225	Feb. 2.6	.335
Feb. 20.2	.025	22.6	.125	24.1	.235	4.2	.325
Mar. 3.5	.015	25.0	.115	25.7	.245	5.7	.315
10.9	+ .005	27.2	.105	27.1	.255	7.2	.305
17.0	— .005	29.4	.095	29.0	.265	8.6	.295
22.2	.015	31.5	.085	30.7	.275	10.0	.285
27.0	.025	Sept. 2.5	.075	Nov. 1.4	.285	11.4	.275
31.4	.035	4.5	.065	3.1	.295	12.7	.265
Apr. 4.6	.045	6.4	.055	4.9	.305	14.0	.255
8.6	.055	8.3	.045	6.7	.315	15.3	.245
12.4	.065	10.2	.035	8.5	.325	16.6	.235
16.2	.075	12.0	.025	10.4	.335	17.8	.225
19.9	.085	13.7	.015	12.3	.345	19.0	.215
23.5	.095	15.5	— .005	14.3	.355	20.2	.205
27.1	.105	17.2	+ .005	16.1	.365	21.4	.195
30.6	.115	19.0	.015	18.5	.375	22.6	.185
May 4.3	.125	20.6	.025	20.8	.385	23.8	.175
7.9	.135	22.3	.035	23.1	.395	24.9	.165
11.5	.145	23.9	.045	25.6	.405	26.0	.155
15.4	.155	25.6	.055	28.4	.415	27.1	.145
19.1	.165	27.2	.065	Dec. 1.3	.425	28.2	.135
23.5	—0.175	28.8	+0.075	4.7	+0.435	29.3	+0.125

Sun's latitude for ecliptic of date $+\Delta\Sigma$ = Sun's latitude, ecliptic of epoch.
If the epoch is January 0.0 of a leap year, add 1 day to all dates of the table prior to March 3.5.

NEW ASTRONOMICAL WORK.

Catalog von 5634 Sternen für die Epoche 1875.0 *aus den Beobachtungen am Pulkowaer Meridiankreise, von* H. ROMBERG. St. Petersburg. 1891. 142 pp. royal 4to.

This catalogue forms the second in the series of secondary catalogues founded upon observations with the Repsold Meridian Circle and intermediate with the epochs of the well known standard catalogues of Pulkowa. The subjects of observation in the present catalogue are double stars in need of reobservation, stars for which proper motion has been computed by ARGELANDER and others, the *Zusatzsterne* of the *Fundamental-Catalog* of AUWERS, and many others, — chiefly those of interest on account of previous use in geodetic, micrometric, or photometric work. The greater part of these stars received at least two observations in each of two positions of the circle; those which received less than this number are, for the most part, of minor interest. The whole number of observations is above 32000, and of these 10000 refer to standard stars. The catalogue-positions in both coordinates are rigorously differential, and are based upon the Pulkowa Standard Catalogue for 1865. The final probable error of one observation is found to be, for the standard stars $\pm 0^s.038$ (reduced to the equator) and $\pm 0''.34$, — for stars between magnitudes 7 and 10, $\pm 0^s.051$ and $\pm 0''.40$. Values of the proper motions as ascertained by ARGELANDER, AUWERS, and occasionally by others, are printed in the columns of the catalogue, and these are employed in the reduction to the epoch of the catalogue; others are given in notes at the foot of the page. Tables near the end of the Introduction exhibit results of comparisons between this catalogue and Pulkowa 1865, the *Fundamental-Catalog* of AUWERS, *Declinations of Fixed Stars* by Boss, *Positiones Mediae*, 1830, and Greenwich 1880. The primary object sought in the reductions has been practically attained, since there appears to be no appreciable systematic difference between the final positions of this catalogue and those of Pulkowa 1865.

CORRIGENDUM.

No. 232, p. 125. M.T. Dec. 11. *for* $9^h\ 51^m\ 9^s$ *put* $7^h\ 51^m\ 9^s$.

ADVERTISEMENT.

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THE SECULAR PERTURBATIONS OF THE *EARTH* PRODUCED BY THE ACTION OF *MARS*.

BY A. HALL, JR.

On account of the slow convergence of the series which express the secular perturbations of the *Earth* by *Mars*, it is desirable, as pointed out by Mr. G. W. HILL (p. 511, Vol. IV, *Astronomical Papers of the American Ephemeris*), that these perturbations should be computed by GAUSS's method, and I have so determined them.

In this method the mass of the disturbing planet is supposed to be distributed along its orbit so as to form an elliptic ring. Call m' the mass of the disturbing planet, T' the periodic time, v' the true anomaly, and $d\mu'$ the quantity of matter along ds', an element of the ring, then the law of distribution is

$$\frac{d\mu'}{m'} = \frac{dt}{T'} = \frac{dv'}{2\pi}$$

The attraction of this ring on any point, which is employed in representing the secular perturbations, can be expressed by elliptic integrals, and so be made as accurate numerically as we please. Then we have to integrate around the orbit of the disturbed planet. This integration is performed by quadratures with reference to the eccentric anomaly. In the solar system we get very accurate results by taking the average of twelve values equally distributed.

In these computations I have followed Mr. HILL, "*On* GAUSS's *Method of Computing Secular Perturbations*," in Vol. I of the *Astronomical Papers of the American Ephemeris*. See, also, TISSERAND, *Méc. Cél.* Tome I, Chap. XXVII.

The perturbations determined here are of the first order with respect to the disturbing forces.

Since in the case of the orbit of the *Earth* the inclination is zero, and the node is indeterminate, we introduce in the place of i and Ω the two variables,

$$p = \sin i \sin \Omega \qquad q = \sin i \cos \Omega$$

Then we have the following formulas for the secular perturbations, the unit of time being the year. The accented letters refer to the disturbing body.

$$\left[\frac{de}{dt}\right]_{00} = \frac{m'n}{1+m} \cos\varphi \,.\, M_E \left[\sin e \,.\, R_0 + (\cos e + \cos E) S_0\right]$$

$$e\left[\frac{d\chi}{dt}\right]_{00} = \frac{m'n}{1+m} \cos\varphi \,.\, M_E \left[-\cos e \,.\, R_0 + \left(\frac{r}{a\cos^2\varphi} + 1\right)\sin e \,.\, S_0\right]$$

$$\left[\frac{dp}{dt}\right]_{00} = \frac{m'n}{1+m} \sec\varphi \,.\, M_E \left[\sin(e+\pi) \,.\, W_0\right]$$

$$\left[\frac{dq}{dt}\right]_{00} = \frac{m'n}{1+m} \sec\varphi \,.\, M_E \left[\cos(e+\pi) \,.\, W_0\right]$$

$$\left[\frac{d\pi}{dt}\right]_{00} = \left[\frac{d\chi}{dt}\right]_{00} + 2\sin^2\frac{i}{2} \,.\, \left[\frac{d\Omega}{dt}\right]_{00}$$

$$\left[\frac{dL}{dt}\right]_{00} = \frac{m'n}{1+m} M_E \left[-2\frac{r}{a} R_0\right] + 2\sin^2\frac{\varphi}{2} \,.\, \left[\frac{d\chi}{dt}\right]_{00} + 2\sin^2\frac{i}{2} \,.\, \left[\frac{d\Omega}{dt}\right]_{00}.$$

M_E denotes the average of values taken with respect to the eccentric anomaly. If R denote the component of the disturbing force in the direction of the radius-vector drawn from the sun to the disturbed body, positive outward from the sun; S the component perpendicular to the radius-vector and in the plane of the orbit, positive in the direction of motion; and W the component perpendicular to the plane of the orbit, positive northward; then we have the following values for R_0, S_0, and W_0:

$$R_0 = \frac{1}{2\pi}\int_0^{2\pi} \frac{ar}{m'} R(1-e'\cos E')dE'$$

$$S_0 = \frac{1}{2\pi}\int_0^{2\pi} \frac{ar}{m'} S(1-e'\cos E')dE'$$

$$W_0 = \frac{1}{2\pi}\int_0^{2\pi} \frac{r^2}{m'} W(1-e'\cos E')dE'$$

For 1850 Jan. 1.0, the elements of the *Earth* and *Mars* are as follows, being taken from LeVerrier, except the values of the masses:

	Earth		*Mars*
	° ′ ″		° ′ ″
L	100 17 3.955	L'	83 40 31.33
π	100 21 41.915	π'	333 17 53.67
☊	indeterminate	☊′	48 23 53.1
i	0 0 0	i'	1 51 2.28
e	0.01677106	e'	0.09326113
n	1295977″.413	n'	689050″.818
a	1.	a'	1.5236914
m	$\frac{1}{325700}$ (Tisserand)	m'	$\frac{1}{3093500}$ (Hall)

We have for the auxiliary quantities which depend upon the elements of the two orbits.

$I = 1°\ 51'\ 2''.28$ $\quad K = 127°\ 3'\ 21''.52$ $\quad \log k' = 9.9999851$

$\Pi = 51\ 57\ 48.84$ $\quad K' = 127\ 4\ 15.01$ $\quad \log C = 8.3051954$

$\Pi' = 284\ 54\ 0.57$ $\quad \log k = 9.9997884$ $\quad C = 0.02019275$

Then, taking on the circumference of the *Earth's* orbit twelve points equally distributed with respect to the eccentric anomaly, we can tabulate the quantities to be computed for each of these points. We can judge whether the computations are performed correctly from the fact that for any quantity the sum of the values for the first, third, fifth, &c., that is for the odd points, should be equal approximately to the sum of the values for the even points. These sums are given, sometimes for the logarithms, and sometimes, when the numbers are small or change sign, for the numbers themselves, and are denoted by S and S'.

E	$\log r$	v	A	$\log B$	ε	$\log g$
°		° ′ ″			° ′ ″	
0	9.9926516	0 0 0.00	3.1200700	0.1378485	119 57 11.91	8.4563620
30	9.9936159	30 29 2.11	3.0340942	0.1146847	154 0 11.06	7.8181272
60	9.9963128	60 50 8.59	3.0259207	0.1125996	189 11 15.15	6.9368224
90	0.0000000	90 57 39.44	3.0978421	0.1324566	223 32 45.39	8.2464664
120	0.0036266	120 19 43.49	3.2306386	0.1651652	255 41 10.19	8.6081340
150	0.0062621	150 28 37.29	3.3886759	0.1992628	285 21 32.40	8.6721320
180	0.0072232	180 0 0.00	3.5295057	0.2263739	313 2 57.84	8.4854992
210	0.0062621	209 31 22.71	3.6153404	0.2417704	339 29 22.24	7.8778120
240	0.0036266	239 10 16.51	3.6232331	0.2433095	5 27 1.42	6.7471148
270	0.0000000	269 2 20.56	3.5511711	0.2307081	31 42 26.56	8.2078912
300	9.9963128	299 9 51.41	3.4185152	0.2055361	59 3 14.38	8.5828900
330	9.9936159	329 30 57.59	3.2607587	0.1719520	88 16 27.03	8.6487052
S			19.9478833	1.0908328	942 22 50.89	0.1394435
S'			19.9478824	1.0908316	1122 22 47.68	0.1394435

E	h	l	G	G'	G''	θ
°						° ′ ″
0	2.3106212	0.7892560	2.3024121	0.8127486	0.0152835	36 42 23.55
30	2.3046900	0.7092114	2.3028975	0.7149991	0.0039953	33 56 11.98
60	2.3029436	0.7027842	2.3027089	0 7035526	0.0005337	33 33 57.19
90	2.3070246	0.7706248	2.3020211	0 7853843	0.0097561	35 54 25.91
120	2.3140156	0.8964302	2.3011715	0.9279674	0.0189931	39 42 13.95
150	2.3180582	1.0504250	2.3017386	1.0855561	0.0188115	43 37 8.69
180	2.3148518	1.1944612	2.3028698	1.2173526	0.0109097	46 46 6.67
210	2.3070842	1.2880634	2.3038590	1.2938207	0.0025321	48 33 55.97
240	2.3038215	1.2992188	2.3035801	1.2996468	0.0001866	48 41 23.19
270	2.3088201	1.2221582	2.3023303	1.2343273	0.0056793	47 8 13.03
300	2.3151389	1.0831835	2.3014891	1.1117907	0.0149575	44 13 17.00
330	2.3157276	0.9218382	2.3016743	0.9590665	0.0201750	40 29 53.29
S	13.8613926	5.9653339	13.8145315	6.0730587	0.0608641	249 39 21.55
S'	13.8614027	5.9653230	13.8145208	6.0731540	0.0609493	249 39 48.87

E	log $\mathfrak{K}$	log $\mathfrak{L}'$	log $\mathfrak{N}$	log N	log P	log Q	log V
0	0.1479366	0.4656226	0.3912212	9.5856612	9.3211710	9.6118260	9.6084156
30	0.1244816	0.4356742	0.3579936	9.5672353	9.2768517	9.5622015	9.5613011
60	0.1215381	0.4318971	0.3537968	9.5707111	9.2779321	9.5621715	9.5620510
90	0.1409012	0.4566603	0.3812866	9.5949822	9.3237505	9.6123228	9.6101371
120	0.1763732	0.5016599	0.4310892	9.6352639	9.4057738	9.7007781	9.6965759
150	0.2188646	0.5549656	0.4898251	9.6830029	9.5067865	9.8072373	9.8031276
180	0.2580295	0.6035476	0.5431073	9.7259931	9.6008969	9.9047785	9.9021186
210	0.2826210	0.6337937	0.5761583	9.7507464	9.6586743	9.9639718	9.9634270
240	0.2843858	0.6359569	0.5785185	9.7479812	9.6599611	9.9610612	9.9640210
270	0.2629317	0.6095926	0.5497204	9.7180753	9.6011927	9.9045581	9.9033297
300	0.2259903	0.5638132	0.4995797	9.6714425	9.5056111	9.8061999	9.802[illegible]562
330	0.1844814	0.5118812	0.4423737	9.6230222	9.4032354	9.6995619	9.695[illegible]5
S	1.2142538	3.2025273	2.7973127	3.9370561	2.7704760	1.5498152	4.5364163
S'	1.2142845	3.2025676	2.7973580	3.9370643	2.7704941	4.5498531	1.5364330

E	log J_1	log J_2	log J	log F_2	log F_1	log R	log S
0°	0.3645956	9.0425063	8.7910839	n9.4089546	n7.7006533	9.3464950	n7.9520966
30	0.3623091	8.7255920	8.8857963	n9.0898372	n6.7115377	9.3193340	n7.5916153
60	0.3617160	n8.2667065	8.8589374	8.6491848	n6.7131528	9.3225043	7.2338965
90	0.3636736	n8.9361226	8.6921251	9.3040068	n7.7152726	9.3546449	7.8610061
120	0.3655626	n9.1218455	8.1432558	9.4848406	n7.9913706	9.4084441	8.0757286
150	0.3654703	n9.1574509	n8.3838783	9.5168396	n7.9982525	9.4712046	8.1543678
180	0.3637743	n9.0660053	n8.7396050	9.1235232	n7.7297905	9.5264161	8.4070970
210	0.3620351	n8.7606257	n8.8449004	9.1196796	n6.8056750	9.5582417	7 8485113
240	0.3616413	8.2133283	n8.8153053	n8.5543310	n6.6212885	9.5569694	n7.1145296
270	0.3628917	8.9286416	n8.6264550	n9.2847192	n7.6845867	9.5220058	n7.9533295
300	0.3648030	9.1114292	n7.8451060	n9.4722186	n7.9726826	9.4632337	n8.1114497
330	0.3657307	9.1406069	8.4929325	n9.5051262	n7.9768599	9.3986551	n8.0959623
S	2.1820928	—0.0114063	+0.0207247	+0.0262429	—0.0306232	2.6240626	+0.0032322
S'	2.1821105	—0.0114063	+0.0207246	+0.0262431	—0.0306233	2.6240861	+0.0032258

E	log W_0	$R_0\sin v$ $+S_0(\cos v+\cos E)$	$-R_0\cos v$ $+S_0\left(\frac{r}{a\cos^2\varphi}+1\right)\sin v$	$W_0\sin(v+\omega)$	$W_0\cos(v+\omega)$	$-2\frac{r}{a}R$
0	8.3809034	—0.0179113	—0.2220726	+0.0236163	—0.0013235	—0.4366964
30	8.4455844	+0.0990802	—0.1837072	+0.0241047	—0.0182461	—0.4111591
60	8.1192556	+0.1851897	—0.0994229	+0.0081631	—0.0248564	—0.4167514
90	8.2779027	+0.2261257	+0.0183173	—0.0037230	—0.0185937	—0.4525586
120	7.6437395	+0.2078778	+0.1517892	—0.0028996	—0.0033133	—0.5165361
150	n8.2690676	+0.1210593	+0.2716812	+0.0175515	+0.0060988	—0.6004779
180	n8.6627276	—0.0255933	+0.3360595	+0.0452167	—0.0082730	—0.6833911
210	n8.8102900	—0.1904412	+0.3076541	+0.0495766	—0.0411298	—0.7337263
240	n8.7807103	—0.3082901	+0.1870194	+0.0211041	—0.0565146	—0.7271533
270	n8.5538661	—0 3324666	+0.0235413	—0.0058473	—0.0353178	—0.6653283
300	n7.8724513	—0.2664850	—0.1191113	—0.0017446	—0.0057504	—0.5762111
330	8.1145834	—0.1485838	—0.2032331	+0.0122245	+0.0044789	—0.4935498
S	—0.0591077	—0.2252122	+0.2342613	+0.0908160	—0.1030612	—3.3567724
S'	—0.0591074	—0.2252265	+0.2342536	+0.0908870	—0.1030100	—3.3568000

Taking one-twelfth of the sum of each of the last five columns, and substituting in the differential equations, we have as values of the secular perturbations, for the rates per Julian year.

$$\left[\frac{de}{dt}\right]_{00} = -48639''.60\, m'$$

$$\left[\frac{d\chi}{dt}\right]_{00} = +3016592''.\, m'$$

$$\left[\frac{dp}{dt}\right]_{00} = +19626''.26\, m'$$

$$\left[\frac{dq}{dt}\right]_{00} = -22258''.37\, m'$$

$$\left[\frac{d\pi}{dt}\right]_{00} = \left[\frac{d\chi}{dt}\right]_{00}$$

$$\left[\frac{dL}{dt}\right]_{00} = -724626''.58\, m'$$

Substituting the assumed value of m', $\frac{1}{3093500}$, in the above values, we have

$$\left[\frac{de}{dt}\right]_{00} = -0''.0157232$$

$$\left[\frac{d\pi}{dt}\right]_{00} = +0''.9751387$$

$$\left[\frac{dp}{dt}\right]_{00} = +0''.0063444$$

$$\left[\frac{dq}{dt}\right]_{00} = -0''.0071952$$

$$\left[\frac{dL}{dt}\right]_{00} = -0''.2342416$$

Mr. Hill, in investigating the motion of the plane of the ecliptic has computed by infinite series $\left[\frac{dp}{dt}\right]_{00}$ and $\left[\frac{dq}{dt}\right]_{00}$ using the same value of m', so that his results are comparable with the above. He finds

$$\left[\frac{dp}{dt}\right]_{00} = +0''.0063362 \qquad \left[\frac{dq}{dt}\right]_{00} = -0''.0072112$$

Naval Observatory, 1891 *July* 7.

ON CHRONOLOGY AND ECLIPSES.

By JOHN N. STOCKWELL.

1. In several numbers of the last volume of this *Journal* I have contributed the results of my studies in regard to the rectification of chronology by means of ancient eclipses. I have since continued these studies during my intervals of leisure; not only for the purpose of verifying and confirming the correctness of my analytical theory of the secular variations of the moon's motion, but also for the purpose of throwing additional light on those chronological questions which are more or less intimately associated with astronomical phenomena. In the present communication I have given the comparison of my calculation of an eclipse of the sun with the observations of the same phenomena by an Arabian astronomer of Bagdad, in the ninth century of our era: and have also availed myself of this occasion to reply to the criticisms of Mr. W. T. Lynn, which recently appeared in the June number of *The Observatory*.

2. In his *Researches on the Motion of the Moon*, Professor Newcomb has given a discussion of twenty-five eclipses observed by the Arabians during the ninth and tenth centuries. The observed and computed times are given in tabular form on page 52. The first is an eclipse of the sun, observed at Bagdad in the year 829 A.D. Nov. 29; and the local mean time of beginning and ending was determined by means of the sun's altitude. From the records of the observations Professor Newcomb has determined the local mean time of beginning, to be 19ʰ 33ᵐ 44ˢ; and the time of ending 21ʰ 24ᵐ 26ˢ. The local times of beginning and ending as calculated by means of Hansen's tables of the sun and moon were 18ʰ 47ᵐ 50ˢ and 21ʰ 6ᵐ 26ˢ. The calculated time of beginning is therefore 45ᵐ.9, and of ending 18ᵐ.0, *earlier* than the observed time. Now the sun must have risen at Bagdad at 18ʰ 51ᵐ 18ˢ; and the calculated time of beginning of the eclipse was therefore 3½ minutes before sunrise. On this subject Professor Newcomb remarks as follows:— "The tables show that the eclipse began at or before sunrise. How a real beginning could have been observed more than half an hour afterward, it is hard to see. The observation is, therefore, clearly inadmissible."

Now according to my data for eclipses, I find that the eclipse commenced at Bagdad at 19ʰ 2ᵐ 42ˢ, and ended at 21ʰ 20ᵐ 24ˢ; and these differ from the observed times of beginning and ending by only 31ᵐ and 4ᵐ respectively; the end agreeing with the observed time as closely as could be desired, considering the roughness of the observations. But the recorded time of beginning was probably about 30ᵐ too late. The residuals show, however, that my data for eclipses, will represent the observations very much more closely than Hansen's tables.

3. In the June number of *The Observatory*, Mr. W. T. Lynn has given some criticisms of the conclusions to which the study of ancient eclipses has conducted me as to the chronology of certain ancient events. I shall here consider the most important of these criticisms.

In regard to the date of the first Olympiad, Mr. Lynn contends that the Olympic festivals were not celebrated in the bissextile years of the Julian calendar; and he gives it as *his opinion* that the date of the first Olympiad has been correctly referred to the year 776 B.C. by the authors of *L'Art de Vérifier les Dates*; but he adduces no evidence that such is really the case. Now since a single *fact* is of more value than a whole volume of opinions, I shall content myself in replying to that part of his criticism, with a single statement.

In Liddell's *History of Rome*, book VI, chap. LXI. §6. I find the following statement of fact, referred to the year 81 B.C., when Sylla celebrated his splendid Triumph for his successes in the Mithridatic War. He says, "Large sums of money were paid into the Treasury. Splendid spectacles followed. *Greece was obliged to suspend her Olympian games*, that her athletes and trained combatants might exhibit their skill and strength before the Roman people. Young men of the noblest family, contrary to old custom, did not disdain to drive chariots at these games."

Now the year 81 B.C. was a bissextile year, and the Olympic games were due, but were not celebrated. The year 481 B.C. was also a bissextile year, and according to the testimony of Thucydides and Herodotus, the Persian army under Xerxes found the Greeks celebrating the same games on their arrival in Greece. These two facts of history abundantly prove that the Olympic games were celebrated in the bissextile years of the Julian calendar; and consequently that they could not have been celebrated in the year 776 B.C.

4. Let us now assume that the first Olympiad was celebrated in the year 777 B.C., and see how perfectly the facts of history will harmonize with that assumption. Historians inform us that Augustus Caesar was born, and that Jerusalem was captured by Pompey in the first year of the *one hundred and seventy-ninth olympiad*. These events therefore happened in the year 65 B.C. Now Josephus informs us (*Antiquities*, Book XVIII, II. 2), that Augustus died at the age of *seventy-seven* years. But 65 B.C. = −64; and −64 + 77 = 13 A.D. Therefore Augustus died in the year 13 A.D., which is the date of his death according to the testimony of the eclipse which occurred during the sedition of the Pannonian legions, as already stated in my former communication.

Mr. Lynn's remark that the historian would be more likely to allude to a total than a partial eclipse, is no doubt correct, if eclipses were the subject of discussion; but in the present case it was the sedition of the Pannonian legions of which he was speaking; and if he mentioned an eclipse at all in that connection it must have been the one with which the event was associated, without regard to its magnitude. And I have shown that that eclipse occurred in October A.D. 13.

Again, according to Josephus, Herod the Great died sixty-one years after the capture of Jerusalem by Pompey. Therefore Herod died in the year 4 B.C.; and this agrees with the date derived from the eclipse mentioned by Josephus, whether that eclipse occurred in the year 5 B.C. Sept. 15, or in the year 4 B.C. March 12–13. The only objection to the latter eclipse being considered as the true one, is the fact that the time between the eclipse and the following Passover, was apparently much too short for the events narrated by Josephus to have taken place.

5. Lastly, a few words in regard to the date of Caesar's Spanish War. Mr. Lynn inadvertently charges me with saying that Caesar commenced his march, after the battle of Soricia, *before* the moon rose, about midnight; whereas the very reverse is what I stated. He also claims that I have mistaken the meaning of the historian in regard to that event; and that the moon actually rose about midday instead of midnight. If that is the case he (Mr. Lynn) should belabor the English translator, Mr. W. A. McDevitte, B.A., of Trinity College, Dublin, rather than myself, for that mistake. Now as this translator probably had no chronological theory to bias his judgement, it seems to me that we may safely trust his translation as to the true meaning of the narrative. He says, "The same day Pompey decamped, and posted himself in an olive-wood over against Hispalis. Caesar, before he removed, *waited till midnight* when the moon began to appear."

Now if Caesar *waited* for the moon to rise, it was because he expected to be benefited by the moonlight, which would certainly have been of great advantage to him in a night-march; but no conceivable benefit could arise from the light of a five-days' old moon in the middle of the day; and any allusion to the moon in that connection would have been simply ridiculous.

The question whether the Spanish War occurred in the "year of confusion," or in the first year of the Julian calendar, may very easily be determined in the following manner: The *mean longitude* of the moon was the same as that of the sun on January 1 of the year 45 B.C.; in other words, the time of *mean new moon* occurred on January 1. The year of confusion contained 445 days; and fifteen lunations contain 443 days. If the year 46 B.C. was the year of confusion, there must have been a new moon on January 2. And if we add the time of three lunations, or 88½ days, we shall find that there was a new moon about the 90th or 91st day of the year. Now in the year of confusion there was an intercalary month of twenty-three days in February, so that the fifth of March would be the 87th day of the year; and consequently would be within three or four days of the time of new moon. And on account of the moon's low southern declination at that time it could not have risen in Spain more than two or three hours before sunrise; and therefore it could not have risen about midnight on March 5, 46 B.C., if that was the year of confusion. On the other hand, if the year 46 B.C. was the first Julian year, the new moon would have taken place on March 12; and on March 5 it would have risen about midnight; and this apparently trifling incident mentioned by the historian has served to fix beyond controversy, the date of Caesar's Spanish War, and the reformation of the Roman calendar.

Almost every modern writer on chronology and the calendar has given the year 45 B.C. as the first year of the Julian calendar; but there is one notable exception; for I find that Thomas Galloway states in the article "*Calendar*," in the eighth and ninth editions of the *Encyclopaedia Britannica*, that the first Julian year commenced with the first [illegible]

January of the year 46 B.C., and the 708th from the foundation of Rome. There must, therefore, be some historical reasons for this statement, which agrees with the conclusions which I have deduced from purely astronomical considerations.

Cleveland, Ohio, 1891 *June* 27.

Postscript. — Since writing the above, I have discovered a little mistake in regard to the "year of confusion." I find that I have given to the months of January and February the number of days corresponding to the Julian year, together with the intercalary month of twenty-three days; which would make March 5 the 87th day of the year; whereas it was the 55th day in the year of confusion. Now the nominal March 5 in the year of confusion corresponds to January 5 in the Julian calendar; so that if the year 46 B.C. was the year of confusion, the battle of Soricia was fought on January 5; but if it was the first Julian year, it was fought on March 5. I have, therefore, calculated the moon's place in the heavens for mean midnight at Rome for both these dates, and have found

For January 5, moon's right-ascension 205° 23′, declination 6° 8′ south.

For March 5, right-ascension 255° 42′, declination 23° 16′ south.

The moon's hour-angle at mean midnight at Rome would therefore be 103° 3′ east on January 5, and 95° 13′ on March 5; and they may be taken as the same for the same local time in Spain.

Now the hour-angle of the moon when in the horizon of Spain with the above declinations would be, in January 85° 0′, and in March 70° 0′; so that in January the moon was $1^h\,12^m$ below the horizon of Spain at midnight, and in March it was $1^h\,41^m$ below.

These quantities are so nearly the same that we cannot decide with any degree of certainty to which date the battle corresponds. But there is another criterion that may perhaps be applied to settle the question whether the year 46 B.C. was the year of confusion, or the first Julian year. If historians can show that the battle of Soricia was fought in midwinter, it was in the year of confusion; but if it was fought in early spring, then it was the first Julian year. The main question, however, is not affected by this circumstance; for it follows in either case that **Caesar**'s War in Spain was in the years 47 and 46 B.C., which is one year earlier than is usually assigned by historians.

It will be noticed that at each of the above dates the moon was something more than an hour below the horizon at midnight, which would seem to imply that the battle was fought a day or two before March 5. On this point the Rev. **Samuel Farmar Jarvis**, in his *Chronological History of the Church*, remarks as follows: "The language of the author is wanting in precision. I should infer from his expressions that the deserters who came to **Caesar**'s camp spoke of the battle and the removal of **Pompey**'s camp as having taken on a previous day; but whether the battle took place, or the slaves gave the information, on the 5th of March, is doubtful."

1891 *July* 6.

THE ACTION OF *JUPITER* UPON COMET *d* 1889,

By CHARLES LANE POOR.

In my note upon this subject in *Astronomical Journal*, No. 228, I stated that the numerical results there published were but a second approximation, the perturbations being considered for only a few months before appulse. Since then I have been over the entire work several times, using more accurate formulas, and have tried to make a very close approximation to the numerical solution of this very interesting problem.

I first obtained a more accurate set of elements, by introducing into the original computation the observations made at the Lick Observatory during the months of November and December, 1890. The resulting elements agree very well with those given by Mr. **Chandler** in his last paper upon this subject, and are as follows:

$$\left.\begin{array}{rcrrr} \pi & = & 1^\circ & 35' & 31''.53 \\ \Omega & = & 17 & 59 & 32\ .97 \\ i & = & 6 & 4 & 13\ .18 \end{array}\right\} 1890.0$$

$$\begin{array}{rcl} \log a & = & 0.5664512 \\ \log e & = & 9.6729017 \\ \log \mu & = & 2.7003308 \end{array}$$

$$T = 1889 \text{ Sept. } 30.355026 \text{ Gr. M.T.}$$

Considering the above elements as osculating for 1889 July 2, I computed the perturbations by *Jupiter* from that date to the time of appulse in October, 1886. Until March 15, 1887, an interval of forty days was used. At this date the perturbations were integrated and applied to the elements, and with the osculating elements thus derived for 1887 March 15, the perturbations were continued until 1886 October 26, using an interval of ten days, when they were again integrated. The elements thus derived for October 26.0 are as follows:

$$\left.\begin{array}{rcrrr} L & = & 215^\circ & 47' & 0''.6 \\ \pi & = & 2 & 37 & 7\ .1 \\ \Omega & = & 19 & 6 & 36\ .3 \\ i & = & 7 & 23 & 37\ .2 \end{array}\right\} 1890.0$$

$$\begin{array}{rcl} \log a & = & 0.5550265 \\ \log e & = & 9.7209782 \\ \log \mu & = & 2.7174669 \end{array}$$

Following the method given by **LaPlace**, I at this point transferred the center of motion from the sun to *Jupiter*, and found the hyperbolic orbit in which the comet was at that moment moving about *Jupiter*. The perturbations due to the action of the sun on the comet, while the latter was traversing this orbit, were then computed. The ordinary method of rectangular coordinates as given by **Watson** was

used. From October 26.0 to August 17.0 a ten-day interval was found satisfactory. But on this latter date the indirect terms in the differential coefficients became too large for convenience, or for accuracy, and it was therefore necessary to apply the perturbations to the elements, and thus to obtain a new set of osculating hyperbolic elements. With these the perturbations were continued until July 24, using a four-day interval, when they were again integrated and applied. It was again found necessary to apply the perturbation on July 4, at which date the interval was increased to ten days, and so continued until March 26.0, on which day the comet passed out of the sphere of *Jupiter's* activity. These various sets of hyperbolic elements are given in the table below.

Hyperbolic Orbit about *Jupiter*.

	Oct. 26.0	Aug. 17.0	July 24.0	July 4.0	Mar. 26.0
	° ′ ″	° ′	° ′	′	° ′
π	282 6 14.3	281 41.49	281 44.50	281 42.85	283 18.33
☊	256 11 20.0	252 18.49	252 11.36	252 12.28	255 8.06
i	68 29 0.8	56 26.11	56 1.63	56 2.00	58 55.36
ω	25 55 12.3	29 23.00	29 33.14	29 30.57	28 40.27
log a	n8.9374383	n8.92681	n8.92450	n8.92423	n8.94800
log e	0.0011062	0.00549	0.00558	0.00558	0.00179
log μ	7.9570528	7.97300	7.97616	7.97686	7.94121
T	Jul.19.0439	19.3273	19.3306	19.3296	20.1238

From these we see that the solar perturbations produce quite marked changes in the relative orbit. The comet passed the center of *Jupiter* on 1886 July 19.33 at no greater distance than that of this planet's radii. The approach was much closer than Mr. Chandler's work indicated, and the resulting changes in the orbit about the sun much more radical, as will be seen from the following elliptical elements deduced from the above for March 26.0.

$$\left.\begin{aligned}\pi &= 188^\circ\ 41'\ 38''.2\\ \Omega &= 182\ \ 53\ \ 13\ .8\\ i &= \ \ 7\ \ 22\ \ 30\ .6\\ \omega &= \ \ 5\ \ 47\ \ 51\ .4\end{aligned}\right\}1890.0$$

$$\begin{aligned}\log a &= 1.0979460\\ \log e &= 9.7513910\\ \log \mu &= 1.9030876\\ T &= 1886\ \text{July}\ 1.58550\\ \text{Period} &= 11.352\ \text{years.}\end{aligned}$$

This seems to indicate only three revolutions in the 107 years to be accounted for in order to establish identity with Lexell's comet: but these revolutions are of unequal periods owing to large perturbations by *Saturn*. The comet, according to my results, was at its shortest distance from *Saturn's* orbit about 1846, and *Saturn* was at the same point in its orbit about 1844.7. I have made a very hurried and rough approximation to the effect of the perturbations by *Jupiter* for a few months before the appulse in 1886, and also to the character of the perturbations by *Saturn* in 1844–1846, and found that the period was shortened considerably. This would seem to indicate that Mr. Schulhof's conclusions regarding this comet are correct.

In the *Bulletin Astronomique* for December, 1889, he found that Tisserand's criterion for the establishment of the identity of two comets can only be satisfied in this case upon the supposition of a strong perturbation by *Saturn*. Assuming the identity of the two comets he deduces by means of this criterion the most probable orbit of the comet between 1779 and 1886, and finds its period to have been about 32 years from 1779 to 1849, at which time it passed near *Saturn*, and its period was thereby increased to about 12 years.

This agrees so strikingly with the results of my direct computation of these intermediate orbits, that there can be, I think, very little doubt as to the identity of the two bodies, and to the conclusion that there were only three revolutions between 1779 and 1886, instead of four as found by Mr. Chandler.

EPHEMERIS OF VARIABLES OF THE *ALGOL*-TYPE

Approximate Greenwich M.T., 1891.

	July		July		July		July		July
	d h		d h		d h		d h		d h
U Cephei	2 8	*U* Cephei	9 20	*U* Ophiuchi	16 9	*Y* Cygni	23 9	*U* Ophiuchi	30 15
Y Cygni	2 9	*Y* Cygni	9 21	Algol	16 13	*U* Ophiuchi	24 18	*Y* Cygni	30 20
U Ophiuchi	3 19	*U* Ophiuchi	10 12	*Y* Cygni	17 9	*U* Cephei	24 19		
Y Cygni	3 21	Algol	10 19	δ Librae	18 10	δ Librae	25 10		August
δ Librae	4 11	*Y* Cygni	11 9	λ Tauri	18 19	*U* Ophiuchi	25 11	*Y* Cygni	1 8
U Ophiuchi	4 15	δ Librae	11 11	*Y* Cygni	18 21	*Y* Cygni	26 8	Algol	2 18
U Cephei	4 20	*Y* Cygni	12 21	*U* Ophiuchi	19 17	*U* Ophiuchi	26 10	*Y* Cygni	2 20
Y Cygni	5 9	Algol	13 16	*U* Cephei	19 19	λ Tauri	26 16	λ Tauri	3 11
U Ophiuchi	5 11	*Y* Cygni	14 9	*Y* Cygni	20 9	δ Librae	27 18	δ Librae	3 17
Y Cygni	6 21	*U* Coronae	14 16	*U* Ophiuchi	20 13	*Y* Cygni	27 20	*U* Cephei	3 18
U Cephei	7 8	*U* Ophiuchi	14 17	δ Librae	20 18	*U* Coronae	28 11	*U* Ophiuchi	3 19
U Coronae	7 18	λ Tauri	14 20	*U* Ophiuchi	21 10	*Y* Cygni	29 8	*Y* Cygni	4 8
Y Cygni	8 9	*U* Cephei	14 20	*U* Coronae	21 11	*U* Ophiuchi	29 19	*U* Ophiuchi	4 15
U Ophiuchi	8 20	*U* Ophiuchi	15 13	*Y* Cygni	21 21	*U* Cephei	29 19	*U* Ophiuchi	5 12
U Ophiuchi	9 16	*Y* Cygni	15 21	λ Tauri	22 17	λ Tauri	30 15	Algol	5 11

SUN-SPOT OBSERVATIONS.

MADE AT THE HAVERFORD COLLEGE OBSERVATORY WITH THE 8-INCH EQUATORIAL

BY F. P. LEAVENWORTH.

1891	Time	Grs	Sps.	Fac Grs	Def. and Size	1891	Time	Grs	Sps.	Fac Grs	Def. and Size	1891	Time	Grs	Sps.	Fac Grs	Def. and Size
Jan. 2	3	0	0	1	bad	Mar. 1	10	1	9	1	poor; small	May 3	2	1	2	2	fair
3	10	0	0	1	poor	2	9	1	5	1	bad	4	10	4	12	4	poor; 1 lar.
4	10	0	0	1	poor	4	12	2	4	3	1 large	5	12	2	9	2	poor; 2 lar.
5	12	1	3	3	fair: small	5	10	3	6	3	fair; 1 lar.	6	9	2	16	2	poor; 2 lar.
6	9	3	7	2	fair	6	10	2	2	0	bad	7	9	3	10	2	poor; 1 lar.
7	9	1	5	2	poor	10	9	1	18	0	fair	8	12	4	35	2	good; 1 lar.
8	4	2	1	1	poor	11	9	1	19	1	fair	9	9	4	44	3	good
9	10	2	3	1	poor	14	9	2	3	3	good; 1 lar.	10	8	4	77	0	good; 1 lar.
12	10	0	0	2	fair	15	9	1	1	3	poor; 1 lar.	11	4	6	40	4	fair; 4 lar.
13	9	0	0	0	good	16	9	3	8	1	poor; 1 lar.	12	10	6	37	3	fair; 2 lar.
14	10	0	0	0	poor	17	9	2	9	1	poor; 1 lar.	13	10	6	16	4	poor; 3 lar.
15	3	1	4	1	fair; 1 lar.	18	10	3	17	2	good; 1 lar.	17	10	4	24	1	fair; 1 lar.
16	10	1	9	1	fair; 1 lar.	23	3	2	7	1		18	10	4	32	3	good; 1 lar.
18	3	3	19	1	fair; 1 lar.	24	3	1	1	2	poor; large	19	9	5	55	3	fine; 5 lar.
19	10	3	21	1	fair; 1 lar.	25	9	1	1	5	fair	20	11	5	40	1	fair; 4 lar.
21	10	1	1	0	bad: 1 lar.	29	3	4	20	2	fair; 1 lar.	21	9	7	59	2	fair
22	4	2	13	0	fair; 1 lar.	30	9	3	8	2	poor; 1 lar.	22	9	9	81	2	fair
23	10	2	23	0	fine; 1 lar.							27	1	4	18	0	bad
24	10	4	28	2	good: 1 lar.	Apr. 5	9	1	15	2	fair; 1 lar.	28	12	5	46	3	poor; 1 lar.
26	2	1	36	3	fair: 1 lar.	6	10	1	1	1	fair; 1 lar.	31	9	3	30	1	fair; 2 lar.
27	9	1	10	3	fair; sev'l l.	7	10	2	6	2	good; 1 lar.						
28	9	1	15	3	fair: sev'l l.	8	12	1	1	1	good; 1 lar.	June 1	10	5	32	2	fair; 3 lar.
30	. .	3	28	1	fair: 1 lar.	9	12	2	9	1	fair; 1 lar.	2	11	6	38	4	good; 2 lar.
						12	3	2	18	0	1 near n.p?	3	9	4	33	3	fair
Feb. 1	2	2	22	0	fair: small	13	9	3	14	2	fair; small	4	11	3	20	1	fair
2	9	3	10	1	good: small	14	9	3	32	1	good; small	8	11	1	11	1	poor
4	9	0	0	1	poor: small	15	9	3	37	2	good	9	11	2	17	0	poor
5	9	1	1	1	poor; small	16	9	4	29	2	poor	10	10	3	29	2	poor; 1 lar.
6	9	1	2	2	fair; small	17	9	3	40	2	good	11	9	3	19	2	poor; 1 lar.
8	10	2	2	1	good: small	19	9	5	32	3	good; small	12	3	5	66	3	fine; 1 lar.
10	10	2	33	0	fair	20	11	3	22	1	poor	13	11	4	24	3	good; 2 lar.
11	11	3	65	0	fair	21	10	4	32	1	good; 1 lar.	14	10	5	39	2	good; 2 lar.
13	3	3	26	1	good: lar.	22	10	5	36	2	good; 2 lar.	15	10	6	47	3	good; 2 lar.
14	9	4	32	1	fair; lar.	23	10	3	92	1	fine; 1 lar.	16	9	6	88	2	good; 2 lar.
15	9	4	54	2	good: lar.	24	10	3	62	1	fair; 1 lar.	17	9	5	100	2	fair; 1 lar.
18	9	5	36	4	fair; 2 lar.	25	10	4	42	3	good; 2 lar	22	9	9	69	5	good: 2 lar.
19	11	1	14	1	bad	26	10	1	34	4	fair: 1 lar.	23	9	7	48	3	good: 3 lar.
22	9	6	55	3	good: { 1 large lar fac	27	. .	1	52	0	fine; 2 lar.	24	9	9	43	3	good; 3 lar.
23	4	4	15	1	good; 1 lar.	28	9	4	58	1	fine; 2 lar.	25	9	8	54	3	{ fair; 2 large immense fac
24	10	3	28	1	fair; 1 lar.	29	9	3	25	1	fair; 1 lar.	26	9	7	108	3	good; 1 lar.
25	10	2	46	3	fair: 1 lar.	30	10	3	26	1	fine; 1 lar.	27	8	6	56	2	poor; 4 lar.
27	9	2	25	1	good; small							28	9	7	70	2	fair; 4 lar.
28	9	1	18	1	good: small	May 1	10	4	29	2	good	29	9	6	61	1	good; 3 lar.
						2	10	3	13	2	good: 1 lar.	30	9	7	35	2	good; 1 lar.

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OBSERVATIONS OF COMPARISON STARS FOR COMET *d* 1889,

WITH THE TRANSIT-CIRCLE AT THE U. S. NAVAL OBSERVATORY.

OBSERVERS, PROF. EASTMAN AND ASSISTANT ASTRONOMER A. HALL, JR.

[Communicated by direction of the Superintendent of the U.S.N. Observatory.

Schjellerup 9800.

			1889.0	1889.0
			h m s	° ′ ″
1889 Dec.	2	H	23 37 53.87	93 55 42.6
	4	H	53.87	40.4
	6	E	53.79	40.3
			53.84	41.10
Corr. for div. error and flexure,				+0.14

Weisse 755.

			h m s	° ′ ″
1889 Dec.	2	H	23 38 50.73	93 47 28.7
	4	H	50.63	28.2
	7	H	50.64	27.2
			50.67	28.03
				+0.08

Schjellerup 9824.

			h m s	° ′ ″
1889 Dec.	2	H	23 40 26.01	94 1 44.9
	11	H	26.01	43.0
	12	E	26.07	43.3
			26.03	43.73
				+0.16

SDM. —3°, 5702.

			h m s	° ′ ″
1889 Dec.	6	E	23 40 46.27	93 37 20.8
	7	H	46.35	22.3
	13	H	46.37	22.9
			46.33	22.00
				+0.09

SDM. —2°, 6037.

			h m s	° ′ ″
1889 Dec.	2	H	23 41 40.94	92 7 33.6
	11	H	41.02	33.1
	21	H	41.08	32.9
			41.01	33.20
				—0.01

Lalande 46612.

			h m s	° ′ ″
1889 Dec.	6	E	23 41 58.56	94 9 11.9
	12	E	58.66	12.7
	13	H	58.67	12.1
			58.63	12.23
				+0.18

Weisse 823.

			1889.0	1889.0
			h m s	° ′ ″
1889 Dec.	4	H	23 42 14.20	93 22 12.4
	22	E	14.26	14.8
	23	H	14.27	13.5
			14.24	13.57
				+0.16

Weisse 847.

			h m s	° ′ ″
1889 Dec.	6	E	23 43 3.29	98 45 44.4
	12	E	3.28	44.9
	21	H	3.42	44.2
	22	E	3.48	45.3
	23	H	3.41	44.8
			3.38	44.72
				+0.28

Schjellerup 9844.

			h m s	° ′ ″
1889 Dec.	7	H	23 43 4.52	94 15 20.8
	11	H	4.56	21.4
	13	H	4.63	22.2
			4.57	21.47
				+0.14

Weisse 945.

			h m s	° ′ ″
1889 Dec.	2	H	23 47 0.04	94 54 39.7
	4	H	0.11	40.1
	11	H	0.12	39.9
			0.09	39.90
				+0.15

Lalande 46859.

			h m s	° ′ ″
1889 Dec.	2	H	23 49 5.73	90 30 29.5
	6	E	5.75	29.1
	12	E	5.73	30.7
			5.74	29.77
				—0.12

DM. —1°, 4500.

			h m s	° ′ ″
1889 Dec.	7	H	23 49 10.50	90 53 58.7
	11	H	10.53	57.2
	13	H	10.67	59.1
			10.57	58.33
				—0.15

Weisse 975.

		1889.0	1890.0
		h m s	° ′ ″
1889 Dec. 6	E	23 49 26.20	95 47 7.3
12	E	26.17	7.9
21	H	26.27	9.4
		26.21	8.20
			+0.19

Weisse 1075.

		h m s	° ′ ″
1889 Dec. 2	H	23 54 19.16	89 31 43.5
4	H	19.18	43.5
11	H	19.15	43.6
		19.16	43.53
			—0.17

Weisse 1090.

		h m s	° ′ ″
1889 Dec. 2	H	23 54 53.27	89 33 7.9
4	H	53.28	6.8
11	H	53.25	5.5
		53.27	6.73
			—0.17

Weisse 1099.

		h m s	° ′ ″
1889 Dec. 6	E	23 55 18.55	95 32 42.8
7	H	18.51	43.1
12	E	18.55	42.9
		18.54	42.93
			+0.11

SDM —5°, 6098.

		h m s	° ′ ″
1889 Dec. 12	E	23 55 37.03	95 30 21.8
13	H	37.04	22.0
21	H	37.02	–
		37.03	21.90
			+0.20

Römker 11914.

		h m s	° ′ ″
1889 Dec. 4	H	23 57 6.54	96 52 33.0
6	E	6.48	34.0
22	E	6.63	34.9
		6.55	33.97
			+0.23

Bonn +0°, 508.

		h m s	° ′ ″
1889 Dec. 2	H	23 57 57.86	89 1 55.1
11	H	57.84	55.6
23	H	57.90	57.3
		57.87	56.90
			—0.15

Weisse 1170.

		h m s	° ′ ″
1889 Dec. 4	H	23 58 49.38	97 34 58.6
23	H	49.50	58.9
		49.44	58.75
			+0.26

Weisse 1179.

		1889.0	1890.0
		h m s	° ′ ″
1889 Dec. 2	H	23 59 5.37	89 4 50.0
6	E	5.30	49.6
11	H	5.32	48.3
		5.33	49.30
			—0.18

Schjellerup 9984.

		h m s	° ′ ″
1889 Dec. 7	H	23 59 15.46	97 53 41.8
12	E	15.62	42.1
21	H	15.68	42.9
		15.59	42.27
			+0.21

Weisse 1218.

		h m s	° ′ ″
1889 Dec. 2	H	0 2 35.04	95 57 44.4
4	H	34.88	44.8
7	H	34.96	44.8
		34.96	44.67
			+0.12

SDM. —7°, 5*.

		h m s	° ′ ″
1889 Dec. 6	E	0 3 2.66	97 8 32.8
12	E	2.91	34.5
13	H	2.77	34.3
		2.74	33.87
			+0.23

Schjellerup 27.

		h m s	° ′ ″
1889 Dec. 2	H	0 1 38.02	95 51 56.0
4	H	37.89	55.6
6	E	37.85	56.2
		37.92	55.93
			+0.17

Schjellerup 48.

		h m s	° ′ ″
1889 Dec. 2	H	0 7 31.73	95 51 33.0
4	H	31.77	32.2
6	E	31.75	33.1
		31.75	32.77
			+0.17

Weisse 135.

		h m s	° ′ ″
1889 Dec. 2	H	0 10 11.35	96 13 5.5
4	H	11.35	5.6
6	E	11.30	6.0
		11.33	5.70
			+0.18

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* Mean A.R. corrected for personal equation (—0ˢ.11) on Dec. 12.

NEW ASTEROID.

An asteroid of the twelfth magnitude was discovered by **Palisa** at Vienna, August 14, in the position.

1891 Aug. 14.4951 Greenw. M.T., $\alpha = 23^h\ 19^m\ 50^s.6$. $\delta = -4°\ 15'\ 36''$.

Daily motion in right-ascension —40ˢ, in declination south 4′.

OBSERVATIONS OF SUN-SPOTS,

MADE WITH A 3-INCH REFRACTOR IN 1891 AT BRYN MAWR, PA., UNTIL MARCH 19, AND AFTER THAT DATE AT PHILADELPHIA, PA.,

By A. W. QUIMBY

1891	Time	Grs.	Sps.	Fac. Grs.	Def.
Jan. 2	2	0	0	0	poor
3	9	0	0	1	fair
4	9	0	0	0	fair
5	9	0	0	0	fair
6	9	1	3	1	fair
7	9	0	0	0	poor
8	9	0	0	0	fair
9	9	0	0	0	poor
10	9	0	0	1	poor
12	9	0	0	0	poor
13	1	0	0	0	poor
14	10	0	0	0	poor
15	9	1	5	2	fair
16	10	1	9	1	poor
18	2	2	15	1	poor
19	9	3	25	1	fair
20	2	1	10	0	v. poor
21	9	3	18	2	poor
22	3	1	10	0	poor
23	9	2	25	0	fair
24	9	4	29	2	fair
25	1	3	70	2	fair
26	1	1	39	3	good
27	9	4	58	2	good
28	9	4	72	3	good
29	2	1	. .	0	v. poor
30	9	3	25	1	poor
Feb. 1	1	2	. .	0	poor
2	9	2	11	3	fair
4	9	0	0	2	fair
5	9	0	0	2	fair
6	9	1	3	2	fair
8	1	0	0	1	poor
10	1	1	27	1	fair
11	9	3	39	4	good
12	9	1	. .	0	v. poor
13	9	2	10	0	poor
14	1	4	50	1	fair
15	9	4	44	3	fair
16	5	0	0	0	v. poor
17	2	1	20	1	poor
18	9	2	27	2	fair
19	9	3	36	2	fair
22	9	2	27	3	fair
23	9	3	37	3	fair
24	9	4	21	3	fair
25	9	1	. .	0	poor
27	9	1	10	2	fair
28	9	1	5	2	fair
Mar. 1	9	1	6	2	fair
2	9	1	5	2	fair
3	9	0	0	0	v. poor
Mar. 1	1	1	3	1	fair
5	8	2	7	2	fair
6	7	1	. .	0	poor
7	9	1	. .	0	poor
8	9	0	0	0	v. poor
10	7	1	17	2	fair
11	9	1	10	2	fair
14	8	2	4	1	fair
15	8	1	. .	0	poor
16	8	1	. .	0	poor
17	8	1	. .	0	fair
18	8	2	9	0	fair
19	8	2	. .	0	poor
21	4	1	. .	0	poor
23	4	1	. .	0	poor
24	5	1	. .	0	poor
25	8	0	0	2	poor
26	8	0	0	2	fair
29	8	1	. .	2	poor
30	8	1	1	2	fair
Apr. 2	8	1	5	0	poor
3	9	1	4	0	poor
4	12	1	. .	0	poor
5	9	1	10	2	fair
6	8	1	. .	0	poor
7	9	1	1	0	fair
8	9	1	1	0	fair
9	1	2	8	1	fair
11	4	1	10	0	poor
12	4	1	16	1	fair
13	9	1	10	0	fair
14	9	2	23	2	good
15	9	2	33	3	good
16	9	2	21	2	fair
17	9	2	30	2	fair
18	2	2	22	1	fair
19	9	2	14	1	fair
20	9	1	10	2	fair
21	9	3	22	2	fair
22	9	2	30	2	fair
23	9	3	80	2	good
24	9	3	78	2	fair
25	9	2	38	3	fair
26	8	2	84	2	good
27	8	2	15	2	fair
28	8	2	18	3	fair
29	8	3	42	2	fair
30	8	2	30	2	fair
May 1	8	2	32	1	fair
2	8	1	. .	1	poor
3	1	0	0	0	poor
4	8	3	9	3	fair
May 5	8	2	5	3	poor
6	8	2	13	3	fair
7	8	2	25	0	fair
8	8	3	21	1	poor
9	8	3	31	1	fair
10	8	3	56	2	fair
11	7	1	49	2	fair
12	7	5	34	2	fair
13	7	5	26	3	fair
14	7	5	16	0	poor
16	10	3	16	0	poor
17	8	3	10	1	poor
18	7	1	37	3	good
19	7	5	15	2	good
20	7	5	61	2	good
21	7	5	83	3	good
22	7	6	71	2	fair
23	7	3	43	0	poor
24	6	2	20	0	v. poor
25	7	5	43	2	fair
26	10	2	. .	0	v. poor
27	12	2	20	2	poor
28	8	3	16	2	poor
30	6	2	15	0	poor
31	8	2	16	2	fair
June 1	10	3	26	2	fair
2	8	1	20	3	fair
3	7	5	21	4	fair
4	8	3	29	2	fair
5	8	2	16	2	fair
6	8	1	10	1	fair
7	6	1	. .	0	v. poor
8	7	1	11	2	fair
9	7	1	35	2	good
10	7	3	37	3	fair
11	7	3	37	1	fair
12	7	3	25	2	poor
13	7	3	27	2	fair
14	7	4	43	2	fair
15	7	6	49	3	good
16	7	6	57	3	good
17	7	5	111	1	good
20	8	5	21	2	poor
21	8	5	39	2	fair
22	7	5	63	6	good
23	6	5	11	1	fair
24	7	5	31	1	fair
25	7	5	66	3	good
26	7	5	127	3	good
27	7	5	63	3	good
28	7	3	49	1	fair
29	7	3	32	3	fair
30	7	4	32	3	fair

OBSERVATIONS OF *HYPERION*.

By A. HALL.

(Communicated by Capt. F. V. McNair, U. S. Navy, Superintendent.)

Date	Wash. M.T.	p	Wash. M.T.	s	Wt.	Remarks.
	h m	°	h m	"		
1889 Feb. 20	9 27.4	262.55	9 32.9	270.29	3	faint
23	9 12.0	247.82	9 19.3	200.71	2	
Mar. 6	8 20.0	60.50	8 26.5	127.80	2	
7	8 34.0	28.62	8 44.5	73.57	2	very faint
8	8 0.0	323.58	8 5.5	72.53	3	faint: doubtful if *Hyperion*
11	9 35.4	271.82	9 42.4	229.78	3	" " "
12	8 27.9	267.05	8 34.4	255.33	3	faint
22	8 36.6	100.92	8 42.6	166.74	2	
26	8 52.0	71.32	8 58.0	180.16	3	
28	8 39.5	36.32	8 46.5	79.53	3	faint
30	8 10.5	291.52	8 17.0	115.04	3	windy
April 2	8 13.0	267.12	8 25.5	241.35	2	very faint
4	9 7.9	259.25	9 15.4	253.72	2	
5	9 5.9	251.95	9 15.1	232.27	3	faint
1890 Feb. 21	10 51.0	256.57	10 57.0	220.47	2	
26	10 0.6	105.15	10 6.1	107.55	3	faint
Mar. 2	9 37.5	81.30	9 43.5	207.16	3	windy, faint
8	9 31.5	276.58	9 40.0	175.46	2	faint
9	9 14.0	271.20	9 19.0	223.69	3	faint
9	9 29.0	261.15	9 34.5	90.70	3	*Titan–Hyperion*
11	7 50.5	265.16	7 56.0	272.83	2	faint
11	8 47.0	269.73	8 52.0	67.93	2	*Titan–Hyperion*
12	8 0.5	263.06	8 23.3	275.80	2	very faint for s
15	8 11.4	253.06	8 18.4	187.79	2	windy
23	9 1.5	82.20	9 7.0	207.95	3	
April 11	9 5.2	93.15	9 12.7	172.74	2	faint
12	7 42.7	88.15	7 50.7	199.18	4	
19	8 33.7	281.75	8 40.7	137.80	3	
21	8 40.2	269.95	8 49.7	227.61	3	faint
22	9 18.2	267.00	9 24.2	252.90	3	faint
1891 April 8	8 36.5	87.28	8 42.0	201.37	3	faint
May 9	8 12.5	268.32	8 18.5	226.57	3	
10	8 12.5	266.20	8 19.0	248.34	2	very faint

NOTE.

Each of the observed angles depends on four settings of the position-circle. The distances are the mean of four measures of the single distance, except in the case of those denoted *Titan–Hyperion*, which are the mean of two double distances. These observations are of *Hyperion* referred to *Titan* as the origin. All the observations have been corrected for differential refraction.

As the observer has been busy finishing his observations of double stars, but few observations of satellites have been made during the present year.

Naval Observatory, 1891 *July* 23.

REDISCOVERY AND OBSERVATIONS OF ENCKE'S PERIODIC COMET.

THE NEBULA N.G.C. 1514.

By E. E. BARNARD.

I have searched carefully for ENCKE's comet with the 12-inch, but, so far, no trace of it can be seen with that instrument.

Examining its place on the morning of August 2 with the 36-inch refractor, I found the comet quite close to the position assigned it by Dr. BACKLUND.

It was extremely faint and diffused, and only very feebly brighter towards the middle. It was about $16\frac{3}{4}$ magnitude, and $\frac{3}{4}'$ in diameter.

The comet could not be found on the 2d because of poor seeing, but on the 3d it was observed again, and was considered brighter.

The comparison-star of August 3 is in the center of the nebula N.G.C. 1514. This is really a large planetary nebula. It is circular, with well-defined outlines. There are several condensations in the nebula, notably, two very marked ones at opposite sides, very roughly (from memory) in position-angles 135° and 315°. The central star is a characteristic feature of most of the planetary nebulae.

Mt. Hamilton, 1891 *August* 4.

FILAR-MICROMETER OBSERVATIONS OF ENCKE'S COMET,

MADE WITH THE 36-INCH EQUATORIAL OF THE LICK OBSERVATORY, BY E. E. BARNARD.

Mt. Hamilton M.T. 1891	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
d h m s			m s	′ ″	h m s	° ′ ″		
Aug. 1 15 17 21	1	2*, 2	+0 25.81	−0 52.3	3 55 46.4	+30 3.2	n9.131	0.223
3 14 57 12	2	2*, 4	+0 19.83	+3 33.1	4 2 47.1	+30 33.7	n9.593	0.350

Mean Places for 1891.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 55 20.1	+0.52	+30 4.0	+2.2	DM. +29° 663
2	4 2 26.7	+0.56	+30 30.1	+2.3	DM. +30° 623

* Δα measured direct with the micrometer on both dates.

EPHEMERIS OF VARIABLES OF THE *ALGOL*-TYPE.

Approximate Greenwich M.T., 1891

	August		August		August		September		September
	d h		d h		d h		d h		d h
Y Cygni	5 20	δ Librae	17 16	*Y* Cygni	29 19	*Y* Cygni	9 7	*R* Can. Maj.	19 16
Y Cygni	7 8	*Y* Cygni	17 20	*U* Ophiuchi	30 15	*U* Ophiuchi	10 13	*Y* Cygni	19 19
λ Tauri	7 13	*U* Cephei	18 17	*Y* Cygni	31 7	*Y* Cygni	10 19	Algol	20 11
U Coronae	7 20	*Y* Cygni	19 8	Algol	31 10	*U* Coronae	11 8	*R* Can. Maj.	20 20
Algol	8 11	*U* Ophiuchi	20 11	*U* Ophiuchi	31 12	*U* Ophiuchi	11 9	*Y* Cygni	21 7
U Cephei	8 18	*Y* Cygni	20 20	δ Librae	31 16	*R* Can. Maj.	11 17	δ Librae	21 11
Y Cygni	8 20	*U* Ophiuchi	21 10			*U* Ophiuchi	12 6	*U* Cephei	22 15
U Ophiuchi	9 16	*U* Coronae	21 15		September	*Y* Cygni	12 7	*Y* Cygni	22 19
Y Cygni	10 8	*Y* Cygni	22 8	*Y* Cygni	1 19	*U* Cephei	12 16	Algol	23 8
U Ophiuchi	10 12	Algol	22 19	*R* Can. Maj.	2 15	*R* Can. Maj.	12 21	*Y* Cygni	24 7
δ Librae	10 17	*U* Cephei	23 17	*U* Cephei	2 16	*Y* Cygni	13 19	*Y* Cygni	[illegible]
Algol	11 8	*Y* Cygni	23 19	*Y* Cygni	3 7	δ Librae	14 15	*U* Ophiuchi	[illegible] 2
λ Tauri	11 12	δ Librae	24 16	*R* Can. Maj.	3 19	Algol	14 18	*S* Cancri	26 18
Y Cygni	11 20	*Y* Cygni	25 8	*U* Coronae	4 11	*Y* Cygni	15 7	*Y* Cygni	27 7
Y Cygni	13 8	*U* Ophiuchi	25 15	*Y* Cygni	4 19	*U* Ophiuchi	15 11	*U* Ophiuchi	27 8
U Cephei	13 18	Algol	25 16	*R* Can. Maj.	4 22	*U* Ophiuchi	16 10	*U* Cephei	[illegible]
U Coronae	14 17	*U* Ophiuchi	26 11	*U* Ophiuchi	5 13	*Y* Cygni	16 19	*R* Can. Maj.	[illegible]
U Ophiuchi	14 17	*Y* Cygni	26 19	*Y* Cygni	6 7	*U* Ophiuchi	17 6	δ Librae	[illegible]
Y Cygni	14 20	*Y* Cygni	28 8	*U* Ophiuchi	6 9	*S* Cancri	17 7	*U* Coronae	[illegible]
U Ophiuchi	15 13	Algol	28 13	δ Librae	7 15	Algol	17 [illegible]	*Y* Cygni	[illegible]
Y Cygni	16 8	*U* Coronae	28 13	*U* Cephei	7 16	*U* Cephei	17 15	*R* Can. Maj.	[illegible]
U Ophiuchi	16 9	*U* Cephei	28 17	*Y* Cygni	7 19	*Y* Cygni	18 7	*Y* Cygni	[illegible]

THE AUGUST *PERSEIDS*, 1891.

By EDWIN F. SAWYER

The members of this annual meteor shower were looked for on the evenings of August 8, 10 and 11; short watches of an hour's duration each being taken on the 8th and 11th, and an extended watch of four hours secured on the 10th, the probable date of maximum intensity. The 9th was cloudy. The sky remained clear on the evenings of observation, and the shower was found to be quite active, and of rather more than the average intensity, the meteors falling at the average rate of about one a minute. Their persistency to grouping was noticeable, as during former displays, and frequently intervals of four or five minutes would occur without a single meteor, to be followed by the simultaneous outburst of four or more. The proportion of *Perseids* was considerably greater than is usually the case, the contemporary showers and sporadic meteors furnishing but a small proportion of the whole number recorded. Of those noted, several were of considerable brilliancy, and three were absolutely stationary, indicating centers of radiation at 40° + 55°, 12½° + 55° and 49° + 57¾°.

Fifty-three tracks were mapped, the majority being very accurately located. Besides the centers of radiation indicated by the stationary meteors, which positions were also supported by several of short tracks, the greater number of the short-path meteors mapped, centered on the main position as at 44¼° + 58°. The following table shows the number of meteors recorded.

Date Aug.	Limits of Watch	Duration	Meteors Seen *Perseids*	Meteors Seen Others	Total
	h m – h m	h			
8	9 50 – 10 50	1	6	5	11
10	9 15 – 10 15	1	37	5	42
"	10 15 – 11 15	1	50	4	54
"	11 15 – 12 15	1	49	4	53
"	12 15 – 13 15	1	50	3	53
11	10 15 – 11 15	1	11	2	13
Total		6	203	23	226

Per cent. of *Perseids*, 89.7; of other meteors, 10.3.

The magnitudes of those recorded were as follows:

	= ♀ or ♃	> 1ᴹ	1ᴹ	2ᴹ	3ᴹ	4ᴹ	5ᴹ	Total
Perseids,	5	4	23	37	43	41	50	203
Others,	0	0	3	3	3	5	9	23
Total,	5	4	26	40	46	46	59	226

METEOR TRACKS MAPPED.

No.	Date	Boston M.T.	Mag.	Observed Path From R.A.	Observed Path From Decl.	Observed Path To R.A.	Observed Path To Decl.	Length of Path	Wt.	Remarks
		h m		°	°	°	°	°		
1	Aug. 8	10 12	♀	150	+65½	172	+53½	16	4	Streak 2 sec., green; passed between Alpha and Beta *Ursae Majoris*
2	" "	10 29	♃	37½	+79½	223	+82	17	4	Streak 1 sec.; across *Polaris*
3	" "	10 48	1	21	+72	32	+67½	6	4	Not a Perseid
4	" 10	9 16	5	341	+65½	347	+60	6	3	Not a Perseid
5	" "	9 22	4	145	+67¾	163	+62½	9	3	Ended at α *Ursae Majoris*
6	" "	9 29	5	10	+71	355	+77	5	4	Short and rapid
7	" "	9 40	5	9	+57½	2	+57	8	3	
8	" "	9 45	2	0	+56¼	342	+53½	11	3	Streak 1 sec.
9	" "	9 55	5	26	+62½	49	+60	11	4	From ε *Cassiopeae*; not a Perseid
10	" "	9 58	1	49	+57¾	. . . .	. . . .	0	4	Stationary 1 sec.
11	" "	10 0	1	40	+82	230	+84	14	3	Across *Polaris*
12	" "	10 14	1	43½	+52¾	60	+53	10	4	Began at γ *Persei*; not a Perseid
13	" "	10 19	♃	51	+59	54	+59	2	1	Very short; streak 1 sec.
14	" "	10 22	5	40	+55	. . . .	. . . .	0	4	Stationary at η *Persei*; ½ sec.
15	" "	10 25	1	27½	+55½	19	+54	5	4	
16	" "	10 45	1	20	+83	290	+85	9	3	
17	" "	10 48	5	9	+75	313	+77½	7	4	
18	" "	10 50	5	19	+59½	12	+60	4	3	From δ to γ *Cassiopeae*
19	" "	11 0	1	25	+80	310	+85	10	4	Streak 1½ sec.
20	" "	11 3	2	170	+85	198	+79	7	4	
21	" "	11 4	4	29	+45	25	+41	5	4	
22	" "	11 7	2	9	+63½	24	+63	7	4	Not a Perseid
23	" "	11 10	3	36	+52	31	+47	6	4	
24	" "	11 13	2	10	+60	354	+57½	9	4	Across β *Cassiopeae*
25	" "	11 17	4	55	+63½	60	+65	3	4	
26	" "	11 20	2	52	+52½	57	+49	4	4	
27	" "	11 25	1	50	+51	54	+48¾	3	4	

No.	Date		Boston M.T.		Mag.	Observed Path				Length of Path	Wt.	Remarks
						From		To				
						R.A.	Decl.	R.A.	Decl.			
			h	m								
28	Aug.	10	11	28	1	260	+83½	240	+71	11	1	Passed across [illegible] *Ursae mi*
29	"	"	11	30	2	14	+55	5	+52	6	4	
30	"	"	11	37	1	37	+59	52½	+61	3	3	Short; streak ½ sec.
31	"	"	11	42	3	17	+60	50	+62	3	4	Short
32	"	"	11	43	4	60	+61½	66	+66½	4	4	
33	"	"	11	47	5	25	+62½	17½	+63	4	1	Began at ε *Cassiopeæ*
34	"	"	11	50	1	13	+54	358½	+48	11	4	
35	"	"	12	5	1	17	+59¼	50	+61¼	2	4	Very short: streak 1 sec.
36	"	"	12	8	1	12½	+55	. . .	. . .	0	1	Stationary: 1 sec.
37	"	"	12	10	1	32	+11	25	+34½	11	4	
38	"	"	12	20	4	20	+57¾	10	+55	6	1	
39	"	"	12	35	2	31	+57½	30	+57¾	2	1	Very short: across θ *Persei*
40	"	"	12	35	2	52	+58	57	+57¾	3	4	Short: streak ½ sec.
41	"	"	12	40	1	39	+50	38	+47½	3	1	Short; streak 1 sec.
42	"	"	12	50	1	45	+10	46½	+33½	7	1	
43	"	"	12	50	4	44¾	+60½	41¾	+62	2	4	Very short
44	"	"	12	55	4	43	+60	43	+61½	2	4	Very short
45	"	"	13	9	4	37	+59	32	+61	3	4	Short
46	"	"	13	11	2	63½	+54	70	+52	5	1	
47	"	"	13	14	3	40	+54½	39	+51	1	1	Nearly stationary
48	"	11	10	35	1	327	+57½	312	+47½	11	4	Long path
49	"	"	10	37	3	45	+56	. . .	. . .	0	1	Stationary; ½ sec.
50	"	"	10	40	2	21	+65	357	+69	10	3	
51	"	"	10	50	1	52	+58½	57	+59½	2	4	Very short
52	"	"	10	50	3	17½	+61	53½	+64½	3	1	Short
53	"	"	11	0	1	48	+65	52½	+70	5	1	

Of the six mapped on the 11th, one was stationary at 45° +56°. Center of observation before 10h was in *Cassiopeae*, afterwards in *Perseus*. In the counts of weights, 4 indicates an accurate observation, 1 a poor one.

Brighton, Mass., 1891 *August* 20.

THE CAUSES OF THE VARIATIONS OF THE TERRESTRIAL MAGNETIC NEEDLE, AND THE UNEXPLAINED MOTION OF THE PERIHELION OF *MERCURY*,

BY FRANK H. BIGELOW.

As the result of my study on the theory of Terrestrial Magnetism and the Variations of the Magnetic Needle, I have shown that the solar radiations are to be regarded as a uniform magnetic field directed positive towards the sun. The astronomical motions of the earth in this field cause the variations of the direction of the lines of force at the surface of the earth polarized like a magnet. The variations theoretically due to the coronal field are of a lower order, and can be detected only by rigorous computations. The law lying behind the theory is also, as with the solar corona, the Newtonian Potential Function in the case of repulsion.

My results have been derived from the discussion of observations made in June, 1883, simultaneously at Point Barrow, Fort Rae, Kingua Fjord, Jan Mayen, Bossekop, Sodankylä, Pawlowsk, Wilhelmshaven, Vienna, Tiflis, Za-kei-wei, Cape Horn, South Georgien. The disturbing forces are illustrated by a model which displays the connection between the observations and the theory.

I will point out the logical consequence that such a magnetic force acting toward the center of the sun, is of the kind required to explain the outstanding movement in the perihelion of *Mercury*, not already included in the law of gravitation.

Washington, D.C., 1891 *August*.

OBSERVATION OF WOLF'S COMET *1884 III*,

MADE AT THE U. S. NAVAL OBSERVATORY WITH THE 9.6-INCH EQUATORIAL.

BY E. FRISBY.

[Communicated by the Superintendent.]

1891 Washington M.T.	⁎	No. Comp.	☄ — ⁎ Δα	☄ — ⁎ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
July 10 13 16 33.5	1	16, 4	—1 21.03	—1 25.3	1 16 0.17	+27 3 17.6	*n*9.688	0.589

Mean Place for 1891.0 of Comparison-Star.

⁎	α	Red. to app. place	δ	Red. to app. place	Authority
1	1 17 20.49	+0.69	+27 4 13.9	—1.0	W.B. 1, 307

CORRIGENDA.

No. 244, p. 25, col. 1, line 10, *for* v' the true anomaly, *put* M' the mean anomaly.

line 13, *for* $\frac{dv'}{2\pi}$ *put* $\frac{dM'}{2\pi}$.

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ORBIT OF THE DOUBLE-STAR Σ186.

BY S. GLASENAPP.

The first micrometrical measure of this double star was made by W. STRUVE in 1825. The relative motion seemed to be rectilinear, but Mr. S. W. BURNHAM (*Sidereal Messenger*, 1891 February, p. 72) has shown that during the last years the angular changes were so considerable that the supposition of an orbital motion is more probable than a rectilinear.

In view to obtain an exact orbit of this binary star, I have collected the following observations:

POSITION OF Σ186 FOR 1891.0.

$\alpha = 1^h\ 50^m\ 16^s, \qquad \delta = +1^\circ\ 18'.5.$

Mag. 7.2 — 7.2, paulo minor.

OBSERVATIONS OF Σ186.

T	θ	σ	Observer
	°	"	
1825.81	60.0	1.37	Σ
30.66	56.95	1.23	H_2
.92	245.6	1.22	Σ
31.80	56.24	0.96	H_2
32.79	68.3	1.16	Σ
33.83	62.9	1.5	Sm.
34.94	65.0	1.18	Σ
41.70	61.3	0.97	Σ
.70	242.8	1.11	O.Σ.
42.77	69.24	0.826	Mädl.
44.18	61.23	0.80	Mädl.
46.11	68.2	0.82	O.Σ
51.88	single	single	Σ
55.90	72.80	obl.	De.
56.50	75.0	0.7	Da.
57.03	78.70	obl.	De.
.92	87.0	0.4	Se.
59.81	81.06	0.5	Da.
.81	83.0	cont.	Se.
62.73	98.0	obl.	De.
63.85	85.0	0.3	Se.
.86	85.15	0.3	Da.
.89	120.0	obl.	De.
66.05	96.0	–	Se.
67.62	–	obl.	De.
1873.93	–	0.5	W.S.

T	θ	σ	Observer
	°	"	
1874.90	145.7	0.23	Newc.
76.99	single	single	Schiap.
77.93	–	0.3	Gled.
78.87	169.0	0.3	β
79.89	0.50	0.31	Hl.
80.02	–	–	W.S.
86.92	205.85	0.5	H. Struve
87.02	199.06	0.27	Sch.
87.89	204.70	0.45	H. Struve
.97	27.19	0.39	K. Tarr.
88.05	206.33	0.28	Schiap.
1890.88	227.1	0.31	β

The observations of Mr. H. STRUVE are made with the large 30-inch refractor, at Poulkova, and were communicated to me personally.

It is to be regretted that this star has not been observed continually. I could not find any measure during nine years between 1866.0 and 1874.9; the star was not measured also during seven years, between 1879.69 and 1886.92. Just at these intervals the angular changes were considerable, and exact measures would have given a more precise material for the investigation of the orbit.

From the above observations I obtain the following annual arithmetical means, which are reduced to the Eq. 1900.

T	θ	Prec.	θ_{1900}	σ
	°	°	°	"
1825.81	60.0	+0.19	60.19	1.37
30.79	61.27	+0.18	61.45	1.22
31.80	56.24	+0.17	56.41	0.96
32.79	68.3	+0.17	68.47	1.16
33.83	62.9	+0.17	63.07	1.5
34.94	65.0	+0.17	65.17	1.18
41.70	62.05	+0.15	62.20	1.04
42.77	69.24	+0.15	69.39	0.83
44.18	61.23	+0.14	61.37	0.80
46.11	68.2	+0.14	68.34	0.82
1855.90	72.80	+0.11	72.91	–

T	θ	Prec	θ_{1900}	σ
				″
1856.50	75.0	+0.11	75.11	0.7
57.17	82.85	+0.11	82.96	0.1
59.82	82.03	+0.10	82.13	0.5
62.73	98.0	+0.09	98.09	–
63.87	96.72	+0.09	96.81	0.3
66.05	96.0	+0.09	96.09	–
73.93	–	+0.07	–	0.5
74.90	145.7	+0.06	145.76	0.23
77.93	–	+0.06	–	0.3
78.87	169.0	+0.05	169.05	0.3
79.89	180.50	+0.05	180.55	0.31
86.97	202.46	+0.03	202.49	0.38
87.97	206.07	+0.03	206.10	0.37
1890.88	227.1	+0.02	227.12	0.31

These observations contain, undoubtedly, considerable occasional and personal errors; therefore it will be very difficult to obtain an exact orbit. The construction of normal positions will facilitate the problem. We divide the above measures in nine groups, and take in each of them arithmetical means, which we consider as normal positions. They are placed in the following table; the number of the last column (n) is equal to the number of the annual means from which is formed each normal position.

NORMAL POSITIONS OF THE COMPANION Σ186.

T	θ	σ	n
	°	″	
1825.81	60.2	1.37	1
32.83	62.9	1.20	5
43.69	65.3	0.87	4
56.20	74.0	0.70	2
58.64	82.5	0.45	2
64.22	97.0	0.30	3
74.90	145.8	0.34	3
79.38	174.8	0.31	2
1888.61	211.9	0.35	3

The investigation of the orbit was made by the method which I exposed in the *Monthly Notices of the R.A.S.*, Vol. XLIX, p. 278, and in a paper, "*Orbites des étoiles doubles du catalogue de Poulkova*" St. Pétersbourg, 1889. I obtained a system of provisional elements, and then, comparing them with the normal positions, I have determined the corrections of ☊ and i, and finally obtained the following elements:

ELEMENTS OF Σ186.

$$\left.\begin{aligned} ☊ &= 55^\circ.2 \\ i &= 72\ .4 \end{aligned}\right\} \text{Eq. } 1900.0$$

$\lambda = 192.4$
$e = 0.300$
$T = 1752.61$
$u = 150.8$ years
$a = 0''.90$
Motion direct.

All the calculations were controlled by my friend, Mr. P. SHAPOVALOFF, at St. Petersburg.

COMPARISON OF THE ELEMENTS WITH THE OBSERVATIONS.

T	θ_o	θ_c	$\theta_o-\theta_c$	σ_o	σ_c	$\sigma_o-\sigma_c$
		°	°	″	″	″
1825.81	60.2	58.1	+2.1	1.37	1.16	+0.21
32.83	62.9	61.2	+1.7	1.20	1.11	+0.09
43.67	65.3	66.8	—1.5	0.87	0.97	—0.11
56.20	74.0	77.4	—3.4	0.70	0.69	+0.01
58.64	82.5	80.6	+1.9	0.45	0.63	—0.18
64.22	97.0	91.2	+5.8	0.30	0.48	—0.18
74.90	145.8	144.0	+1.8	0.34	0.27	—0.07
79.38	174.8	177.6	—2.8	0.31	0.30	+0.01
1888.61	211.9	215.0	—3.1	0.35	0.49	—0.14

Though the differences between the observations and the elements are not considerable, I think that a definitive conclusion on the orbit can be obtained only at the end of the present century, when the angle of position will have described an arc of 200°.

Astronomers possessing large telescopes should give attention to this interesting double star.

MEASURES OF THE POSITION-ANGLES OF THE RINGS OF *SATURN*,

BY E. E. BARNARD.

The past apparition of *Saturn* gave a good opportunity for a redetermination of the inclination of the rings. For this purpose I began a series of measures of position-angles in March, with the 12-inch equatorial. These have been kept up until the low altitude of the planet made it unadvisable to continue the measures. In all, thirty nights' observations were obtained.

In the observations, the eyes were kept parallel with the major axis of the rings. A number of observations with the eyes at right-angles to this, showed no sensible or real difference in results by the two methods.

A magnifying power of 175 was used throughout. Experiments with 500 diameters showed a strict agreement with the measures made with the lower power. The settings, however, were easier with 175, since both ends of the rings could be seen at once, while with the higher power it

was necessary to glance from one end of the rings to the other in setting the wires. When the measures were begun the rings were somewhat open; the extreme ends of these were bisected. Later, however, the rings became more linear, and the wires could be placed with more certainty.

Usually five settings were made. The average time required for all the settings of each night was five minutes.

The observations are corrected for refraction through the "parallel" determinations. On each night this parallel was obtained by some star very near to *Saturn*, and when no star was near enough, the planet itself was used. Two settings were always made for these values. Determinations immediately before and after the measures showed no sensible difference in the parallel.

These observations alone cannot determine the inclination of the rings, without a knowledge of the accurate time of their disappearance, which cannot be observed this year, the planet being with the sun at the critical time. I have, therefore, decided to publish the observations as a correction to the position-angles derived from the data given in the *American Ephemeris*. They will be available for a determination of the inclination when the position of the plane of the rings becomes better known.

During these observations, and at other times throughout the opposition, no spots of any kind were seen on the planet, although it was observed with all magnifying powers under the most favorable circumstances. No unaccountable phenomena were witnessed as the rings closed in. Perhaps some of the singular phenomena that have been noticed during similar phases, at previous disappearances, could be traced to imperfect seeing.

From the residuals, it appears that the probable error of a single night's observations was ±0°.15, and the probable error of the thirty nights' work, ±0°.028. These observations, therefore, give the correction to the position-angles derived from the *American Ephemeris*,

—3′.36 ± 1′.68.

Position-Angles of the Rings of *Saturn*.

1894	Mt. Hamilton M.T.	P. A.	Set.	See.	C—O
	h m	°			°
March 23	9 54	84.27	4	3–4	+0.49
24	8 52	84.78	4	1–5	—0.57
25	9 33	84.79	4	. .	—0.43
April 20	6 53	84.73	5	5	—0.39
21	7 23	84.35	4	5	—0.01
May 21	8 4	84.46	5	. .	+0.16
22	7 35	84.63	5	1–2	—0.33
24	7 22	84.23	5	4–5	+0.02
June 14	7 57	84.44	5	4	—0.06
15	7 29	84.51	5	4–5	—0.16
18	7 41	84.71	5	1	—0.35
21	8 7	84.60	7	1–2	—0.22
22	7 39	84.63	6	2–3	—0.24
30	7 57	84.63	5	4	—0.18
July 1	8 13	84.58	5	4	—0.12
2	8 41	84.49	5	4	—0.02
3	8 36	84.51	5	. .	—0.03
5	7 55	84.36	5	4	+0.43
9	7 46	84.62	5	3	—0.40
12	8 4	84.47	5	3–4	+0.07
13	8 0	84.08	5	4	+0.44
14	8 11	84.45	5	4	+0.08
15	7 59	84.68	5	3–4	—0.14
20	8 4	84.34	5	3	+0.28
24	7 46	84.66	5	4	—0.05
26	7 44	84.56	5	2	+0.07
28	7 36	84.87	5	1–2	—0.22
31	7 58	84.34	5	4	+0.33
Aug. 9	7 23	84.85	5	3	—0.10
14	7 31	84.71	5	1–2	+0.08
Mean deviation			. .	. .	—0.056

The number of individual settings of the wires is given in the column "Set." The steadiness of the image is indicated in column "See." On this scale 5 would be perfect seeing or steadiness. The last column contains the residuals from a comparison with the *American Ephemeris*.

Mt. Hamilton, 1894 *August* 24.

ANCIENT CHRONOLOGY AND ECLIPSES.

By W. T. LYNN.

As Mr. Stockwell does me the honor to refer to me in his article in No. 244 of the *Astronomical Journal* on the above subject, may I ask the favor of the insertion of these few lines?

In the first place, I must acknowledge an inadvertence in my letter in the June number of *The Observatory*. In lines eight and nine of that letter I should have written that the years in which the Olympic festival was celebrated, followed (not "preceded") by one year those which were bissextile in the Julian calendar. This I did not give as the *opinion* of myself or any one else, but stated that I considered the authors of *L'Art de Vérifier les Dates* had so satisfactorily proved it (see their Vol. I. pp. xxiii and xxxix) that further discussion was unnecessary.

1. Mr. Stockwell refers to the year B.C. 81 as that of Sulla's triumph for his successes in the Mithridatic War. That year undoubtedly corresponded to a bissextile, and as we are told that the Olympic games (except the horse-races) were suspended by order of Sulla, that the Greek athletes might take part in the spectacles exhibited by him at Rome. Mr. Stockwell argues that that year was also a year in which the games were due. Appian is, I believe, the sole

authority for the suspension of the games. He does not connect it with SULLA's triumph, nor could it have been at the same time, because the latter was at the beginning of February, and the games were always held at mid-summer. SULLA did not resign his dictatorship until B.C. 79, and the spectacles in question may have been shown in B.C. 80. APPIAN expressly says that SULLA's object was to give the people a long rest from warlike contests and feelings.

2. Mr. STOCKWELL says that the year of the birth of AUGUSTUS CAESAR, and of the taking of Jerusalem by POMPEY, was B.C. 65, which corresponded to a bissextile; and says that historians tell us that these events happened in the first year of the one hundred and seventy-ninth Olympiad. The only historian, I believe, who gives the Olympiad of the capture of Jerusalem is JOSEPHUS. He does not mention what year of the quadrennial period of the Olympiad it was in, leaving that to be inferred from the consulate. The year was a remarkable one in several respects, being also that of the conspiracy of CATALINE. There is little doubt that it was B.C. 63, not 65. Mr. STOCKWELL refers to JOSEPHUS as saying that AUGUSTUS was seventy-seven at the time of his death, and as he contends that the latter event occurred in A.D. 13, he thinks this a great confirmation of his view. But surely on such a point the authority of SUETONIUS is far preferable to that of JOSEPHUS, and the former says distinctly that AUGUSTUS was in his seventy-sixth year at the time of his death. Taking his birth as B.C. 63 (= −62), I contend that this completely confirms the view that he died in A.D. 14.

3. Space does not allow much reference to Mr. STOCKWELL's third point, the date of CAESAR's Spanish War. I gave no translation, but the original passage, and still think that "hora VI" by itself means midday, and that the historian does not mean that CAESAR waited (that word is *not* in the original) for moonlight and made a night-march, but that he thought it a somewhat remarkable circumstance that the small crescent moon was distinctly visible in the middle of the day.

4. As Mr. STOCKWELL makes no further mention of the battle of Pydna, I presume second thoughts have shown him that his suggestion to alter the received date of that battle by four years is untenable.

Blackheath, London, S.E., 1891 *August* 14.

EPHEMERIS OF WOLF'S PERIODIC COMET (*1884 III*),

BY WILLIAM BELLAMY.

(Continued from page 18.)

Gr. M.T.	App. α	App. δ	log Δ	Gr. M.T.	App. α	App. δ	log Δ
1891	h m s	° ′ ″		1891	h m s	° ′ ″	
Sept. 7.5	3 47 4.97	+23 13 53.9	9.99871	Oct. 1.5	4 27 11.18	+13 46 14.9	9.93327
8.5	49 10.57	22 55 59.1		2.5	28 19.91	13 16 56.9	
9.5	51 14.28	22 37 33.0	9.99265	3.5	29 25.83	12 47 17.0	9.92893
10.5	53 16.05	22 18 35.6		4.5	30 28.93	12 17 16.1	
11.5	55 15.83	21 59 7.1	9.98665	5.5	31 29.21	11 46 55.3	9.92484
12.5	57 13.59	21 39 7.5		6.5	32 26.65	11 16 15.5	
13.5	3 59 9.28	21 18 37.0	9.98073	7.5	33 21.23	10 45 17.8	9.92103
14.5	4 1 2.86	20 57 25.7		8.5	34 12.95	10 14 3.4	
15.5	2 54.29	20 36 3.7	9.97491	9.5	35 1.81	9 42 33.6	9.91752
16.5	4 43.53	20 14 1.4		10.5	35 47.81	9 10 49.5	
17.5	6 30.53	19 51 28.9	9.96919	11.5	36 30.94	8 38 52.4	9.91432
18.5	8 15.26	19 28 26.4		12.5	37 11.21	8 6 43.5	
19.5	9 57.68	19 4 54.2	9.96359	13.5	37 48.63	7 34 24.3	9.91146
20.5	11 37.73	18 40 52.6		14.5	38 23.19	7 1 56.2	
21.5	13 15.39	18 16 22.0	9.95812	15.5	38 54.91	6 29 20.5	9.90894
22.5	14 50.61	17 51 22.7		16.5	39 23.78	5 56 38.8	
23.5	16 23.35	17 25 55.1	9.95279	17.5	39 49.83	5 23 52.5	9.90679
24.5	17 53.56	16 59 59.6		18.5	40 13.08	4 51 3.3	
25.5	19 21.21	16 33 36.7	9.94763	19.5	40 33.53	4 18 12.7	9.90502
26.5	20 46.25	16 6 46.9		20.5	40 51.20	3 45 22.2	
27.5	22 8.65	15 39 30.7	9.94264	21.5	41 6.11	3 12 33.6	9.90364
28.5	23 28.37	15 11 48.7		22.5	41 18.27	2 39 48.5	
29.5	24 45.39	14 43 41.6	9.93784	23.5	41 27.72	2 7 8.7	9.90267
30.5	4 25 59.67	+14 15 10.1		24.5	4 41 34.48	+ 1 34 35.9	

Gr. M.T.	App. α	App. δ	log Δ	Gr. M.T.	App. α	App. δ	log Δ
1891	h m s	° ′ ″		1891	h m s	° ′ ″	
Oct. 25.5	4 41 38.60	+1 2 11.9	9.90212	Nov. 18.5	4 32 53.04	−9 58 5.0	9.92948
26.5	41 40.12	+0 29 58.1		19.5	32 14.39	10 18 12.9	
27.5	41 39.08	−0 2 2.7	9.90200	20.5	31 35.23	10 37 37.5	9.93439
28.5	41 35.52	0 33 49.6		21.5	30 55.65	10 56 18.2	
29.5	41 29.50	1 5 20.6	9.90232	22.5	30 15.75	11 14 14.8	9.93965
30.5	41 21.08	1 36 33.8		23.5	29 35.62	11 31 27.0	
31.5	41 10.34	2 7 27.1	9.90308	24.5	28 55.37	11 47 54.6	9.94523
Nov. 1.5	40 57.33	2 37 59.6		25.5	28 15.10	12 3 37.5	
2.5	40 42.13	3 8 8.7	9.90429	26.5	27 34.90	12 18 35.7	9.95111
3.5	40 24.82	3 37 53.0		27.5	26 54.88	12 32 49.0	
4.5	40 5.49	4 7 10.7	9.90595	28.5	26 15.14	12 46 17.6	9.95728
5.5	39 44.23	4 36 0.2		29.5	25 35.77	12 59 1.7	
6.5	39 21.11	5 4 20.1	9.90805	30.5	24 56.87	13 11 1.5	9.96372
7.5	38 56.22	5 32 8.8		Dec. 1.5	24 18.53	13 22 17.2	
8.5	38 29.67	5 59 24.9	9.91059	2.5	23 40.84	13 32 49.4	9.97041
9.5	38 1.53	6 26 7.2		3.5	23 3.88	13 42 38.5	
10.5	37 31.90	6 52 14.5	9.91356	4.5	22 27.73	13 51 41.0	9.97732
11.5	37 0.89	7 17 45.5		5.5	21 52.48	14 0 9.3	
12.5	36 28.59	7 42 39.1	9.91695	6.5	21 18.19	14 7 52.3	9.98444
13.5	35 55.09	8 6 54.4		7.5	20 44.94	14 14 54.7	
14.5	35 20.49	8 30 30.4	9.92074	8.5	20 12.78	14 21 17.1	9.99174
15.5	34 44.89	8 53 26.2		9.5	19 41.79	14 27 0.3	
16.5	34 8.38	9 15 41.0	9.92492	10.5	19 12.01	14 32 5.1	9.99921
17.5	4 33 31.07	−9 37 14.2		11.5	4 18 43.49	−14 36 32.5	

ON THE RIGHT-ASCENSION OF ξ *DRACONIS*.

BY GEORGE C. COMSTOCK.

My attention has recently been called to the tabular right-ascension of this star as given in the *Berliner Jahrbuch* by the systematic discordance between clock corrections derived from it and from other stars situated in the same part of the heavens. In view of the revision of the star-places of AUWERS's *Fundamental Catalog*, which may be expected at no very distant date, it does not seem advisable to make an exhaustive discussion of all the material available for a determination of this right-ascension, but I have collated the determinations of the better class which are most readily accessible to me. Using the elements of the star's motion given in the *Fundamental Catalog* I obtain the following values of the right-ascension for the epoch 1875.0.

Authority	Epoch	Obs.	Syst. Corr.	R.A. '75 17ʰ 51ᵐ	Corr'd R.A.	Wt.
			s	s	s	
Bradley	1751.3	2	0.00	22.57	21.83	0
Struve	1824(?)	13	+ .02	22.38	22.06	2
Pond	1830(?)	8	− .03	22.36	22.08	1
Pulkowa '45	1848.1	51	+ .01	22.21	22.04	2
Pulkowa '65	1865.6	41	.00	22.13	22.07	3
Rogers	1871.4	25	.00	22.07	22.07	3
Ten Year Catal	1881.2	5	+ .06	22.02	22.06	1
Brown	1888.9	5	.00	21.99	22.08	2

The last determination of the table is the result of unpublished observations made with the meridian circle of the Washburn Observatory, in the years 1888–89, by Professor S. J. BROWN, U.S.N. The systematic corrections contained in the table above have been applied to the catalogue places. The sequence of the numbers in the column R.A. 1875 indicates clearly that the proper motion adopted in the *Fundamental Catalog*, $+0^s.0169$, is considerably in error, and from a graphical treatment of the data I find as the correction to this quantity, $\Delta\mu = -0^s.0062$. Correcting the several right-ascensions for this change in the proper motion, I obtain the quantities given in the column "Corr'd R.A." I have assigned to the several determinations the weights given in the last column of the table, and find as the mean result, for the epoch 1875.0,

$$\text{R.A.} = 17^h\ 51^m\ 22^s.066\ ,\quad \mu = +0^s.0107.$$

The resulting correction to the tabular right-ascension of the *Berliner Jahrbuch* is

$$\Delta\alpha = -0^s.123\ -0^s.0062\ (T-1875).$$

At present the tabular right-ascension is nearly a quarter of a second in error.

Washburn Observatory, 1891 *September*.

ON A CLASSIFICATION OF THE PERIODIC COMETS BY THEIR PHYSICAL APPEARANCE.

BY E. E. BARNARD.

I have never seen any classification of the short-period comets, arranged according to their physical peculiarities. Such a classification, it seems to me, would be valuable in several directions.

These comets can be readily divided into two distinct classes, and perhaps into three. My experience does not extend over a sufficiently great length of time to classify many of these bodies, but it might be well to identify even the few that I am familiar with.

To the first of these classes I would assign those comets which are large, round and very gradually brighter in the middle, with no special condensation, and of a very diffused nature. They are from one to several minutes in diameter, and have no nucleus or tail. These are distinctly periodic. Indeed, I have seen no representative of this class that was not periodic. So characteristically peculiar are these in appearance, that I would venture a prediction, upon a mere telescopic inspection alone, that the object was a periodic comet. Trusting to this peculiarity, I predicted, at the first observation, that the comet discovered by SWIFT, 1889 Nov. 16, was of short period (see *A. J.* 207). A similar prediction was made at the first observation of D'ARREST'S comet in 1890, when I supposed the discovery was an entirely new comet (see *A. J.* 227).

There are very few nebulas that resemble this class of comets.

In this *Class I* I would put the following comets:

D'ARREST'S.
SWIFT'S, 1880 (TEMPEL, 1869).
BARNARD'S, 1884 II.
BROOKS'S, 1886 IV.
SWIFT'S, 1889 VI.

To this class also belongs the comet discovered by me 1889 June 23 (III), to which Dr. BERBERICH has assigned a period of 128 years. Certainly, from the appearance of ENCKE'S comet when first seen this year on Aug. 1, it should be classed with the above, but later it usually develops a strong condensation and a small tail. Perhaps it belongs to a third class: it certainly does not belong to the second. The most distinctive members of the first class are D'ARREST'S, SWIFT'S 1880, BROOKS'S 1886 and SWIFT'S 1889. My comet of 1881, at the first stages of its appearance, was a perfect example of *Class I*, but later it became strongly condensed, and might be assigned to a third class with ENCKE'S, for it in no way resembled the members of *Class II*. Perhaps it and ENCKE'S comet should be assigned to *Class I*, with a slight modification of the description to suit all stages of their visibility.

30.5 4 27
1891 *August* 31.

It is not possible to follow comets of *Class I* any very great distance, for, from their large, diffused nature, they soon become lost in space. A very large telescope is of no special value in following them, and it is safe to predict that none of them will ever be seen near aphelion.

The second is a much larger and less exclusive class. To this I would assign those comets which are comparatively small, and which have an indefinite central brightness or nucleus, and which often have an incipient bushy tail. The principal characteristics of these, however, are their smallness and indefinite nuclei. These peculiarities are more pronounced when the comet is coming first into view, or is disappearing. Many of the parabolic comets resemble these, and there are hundreds, and perhaps thousands of nebulas just like them in appearance.

To this *Class II* I would assign

FAY'S.
WOLF'S 1884 III.
FINLAY'S 1886 VII.
BROOKS'S 1889 V.
SPITALER'S 1890.

Observations of this class of comets can be made with more precision than of those of the first class, and their orbits ought consequently to be better known.

Identical in appearance with these, are comets 1889 I and 1889 II. The first of these has proved to be hyperbolic, and the second has been assigned an elliptic orbit of very long period, by MILLOSEVICH.

When receding from the sun these comets become very small, scarcely anything remaining in sight but the small indefinite stellar brightness which is characteristic of them. This can be followed to very great distances, the almost stellar nature of the central brightness giving full scope to the superior power of the great instruments of to-day. That some one of these comets will be followed completely around its orbit some day, is only a matter of a reasonable increase in our present telescopic power.

Comet 1889 I, an exact counterpart of this class, was followed here with the 36-inch refractor beyond the aphelion distances of most of the short-period comets. It was an easy object at a distance of 6.25.

Whether the peculiarities of these two distinct classes of short-period comets permits any speculation as to their relative ages, it is, perhaps, too early in the history of any of them to be able to tell.

OBSERVATIONS OF VARIABLE STARS, 1891.

BY PAUL S. YENDELL.

2478 *R Lyncis.*

A series of nine observations, from 1891 April 27 to May 28, shows a well-defined maximum to have been passed on May 13.7. The star's light was, by eye-estimation, $8^{M}.0$ ± at maximum.

3796 *U Hydrae.*

Eleven observations of *U Hydrae*, from March 29 to May 6, show a maximum of $5^{M}.4$ to have occurred on May 11.6.

4521 *R Virginis.*

Seven observations of this star have been obtained between May 3 and June 25; these indicate a maximum about June 10.

4557 *S Ursae Majoris.*

When first observed, on April 28, *S Ursae* was about $11^{M}.0$ by estimation; it rose rapidly and pretty steadily to a maximum of $7^{M}.6$, which, according to my observations, 25 in number, was passed June 29; the star has since slowly and steadily declined, until on Sept. 2, its estimated magnitude was 8.8.

5770 *R Herculis.*

Eight observations of this star, from April 29 to Sept. 4, indicate a maximum on August 24.5. The maximum phase was sharply marked, the increase and decrease both being rapid and apparently regular; the greatest observed light was $8^{M}.5$.

5955 *R Draconis.*

This star was first observed, at a magnitude of about 9.3, on March 29; a maximum was passed on May 19; the average light at this phase was about $7^{M}.9$. When last observed, August 2, its light was estimated as, at most, of the $10^{M}.0$, and the star has not since been seen.

6088 *V Herculis.*

I have obtained three observations of this star during the present year, as follows: April 29, $11^{M}.+$; June 7, $11^{M}.0$; August 6, $< 10^{M}.0$. The star has always been near the limit of visibility with the power used (30 on a $4\frac{1}{4}$-inch refractor), and the observations accord well with several made in 1890. The present variation of the star, seems, to say the least, doubtful.

7456 *RR Cygni.*

This star has been carefully watched since May 28, and the following phases are deduced from a reduction of the observations up to this date:

MAXIMA	M	MINIMA	M
1891 July 10	8.8	1891 June 7	9.3
Aug. 28	8.7	July 26	9.3

7560 *R Vulpeculae.*

This star was observed, from July 5 to August 22, six times; a maximum is sharply indicated on July 30.6; the estimated maximum light was about $8^{M}.3$.

Dorchester, Mass., 1891 *September* 5.

MEASURES OF THE BINARY STARS, β *DELPHINI* AND 85 *PEGASI*.

BY S. W. BURNHAM.

I have recently finished sets of measures of these two interesting binary systems. The observations were all made with the 36-inch refractor.

β Delphini (β 151).

	°	″
1891.389	326.6	0.38
.419	332.0	0.38
.449	332.4	0.33
1891.559	335.1	0.45
1891.45	331.6	0.38

85 *Pegasi* (β 733).

A AND B.

	°	″
1891.537	150.4	0.79
.540	153.2	0.86
1891.600	151.7	0.73
1891.56	151.8	0.79

Lick Observatory.

A AND C.

	°	″
1891.540	354.8	24.38
.575	354.9	24.57
1891.600	354.3	24.79
1891.56	354.7	24.58

The close star of the last named system is at all times difficult with the large telescope, and as it requires a power of not less than 1500, it can only be measured on the best nights.

I requested Mr. SCHAEBERLE to test my recent measures by comparing them with the theoretical places of the companion according to his orbit, and he has computed an ephemeris which covers the unexpired part of the period. My measures of last year on four nights gave, 139°.0: 0″.78 (1890.55). The differences between the observed and computed places are as small as could be expected when the extreme difficulty of the object is considered.

EPHEMERIS OF β 733 (85 *PEGASI*).

By J. M. SCHAEBERLE.

In No. 185 of the *Astronomical Journal* I published an orbit and ephemeris of this interesting binary, discovered by Mr. BURNHAM in 1878. As the motion in position-angle is so rapid and variable, the four-year interval in the published ephemeris is too great for convenient use in comparing the observed and computed places. I have, therefore, reduced the interval to one year, each place being computed directly from the elements.

The positions for 1896.0, as given in No. 185 of the *Astronomical Journal*, should read $P = 184°.6$, $D = 0''.54$.

The last two equations in page 407 of KLINKERFUES'S *Theoretische Astronomie* should read.

$$\rho \cos(p - \Omega) = r \cos(v + \lambda - \Omega)$$
$$\rho \sin(p - \Omega) = r \cos i \sin(v + \lambda - \Omega)$$

Mt. Hamilton, 1891 *August* 31.

EPHEMERIS OF β 733.

Date	P	D
	°	″
1889.5	132.2	1.02
1890.5	137.1	1.01
1891.5	142.2	0.97
1892.5	147.9	.90
1893.5	155.0	.80
1894.5	164.0	.69
1895.5	176.3	.59
1896.5	194.3	.51
1897.5	216.8	.47
1898.5	240.2	.47
1899.5	259.9	0.51

NEW ASTEROIDS.

Telegraphic announcements have been received of the discovery of the following asteroids:

One of the twelfth magnitude, by CHARLOIS, at Nice.
1891 Aug. 28.5334 Greenw. M.T. $\alpha = 0^h\ 12^m\ 12^s.6$, $\delta = +2°\ 16'\ 2''$. Daily motion, -36^s in α, and 1′ southward.

One of the eleventh, by PALISA, at Vienna.
1891 Aug. 30.5377 Greenw. M.T. $\alpha = 23^h\ 1^m\ 17^s.7$, $\delta = -1°\ 26'\ 23''$. Daily motion, -52^s in α, and 9′ southward.

One of the thirteenth, by CHARLOIS.
1891 Sept. 1.5245 Greenw. M.T. $\alpha = 0^h\ 12^m\ 51^s.9$, $\delta = +11°\ 48'\ 3''$. Daily motion, -12^s in α, and 9′ southward.

One of the thirteenth, by PALISA.
1891 Sept. 4.4148 Greenw. M.T. $\alpha = 23^h\ 24^m\ 15^s.1$, $\delta = -4°\ 9'\ 16''$. Daily motion, -56^s in α, and 8′ southward.

One of the thirteenth, probably *Alice*, by PALISA.
1891 Sept. 4.4202 Greenw. M.T. $\alpha = 23^h\ 25^m\ 20^s.3$, $\delta = -1°\ 12'\ 50''$. Daily motion, -18^s in α, and 7′ southward.

One of the thirteenth, by CHARLOIS.
1891 Sept. 8.4628 Greenw. M.T. $\alpha = 23^h\ 0^m\ 43^s.7$, $\delta = -8°\ 11'\ 26''$. Daily motion, -44^s in α, and 5′ southward.

One of the eleventh magnitude, by CHARLOIS.
1891 Sept. 11.4753 Greenw. M.T. $\alpha = 21^h\ 41^m\ 43^s.5$, $\delta = -14°\ 5'\ 18''$. Daily motion, -36^s in α, and 4′ southward.

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ADDITIONAL TERMS IN THE GREAT INEQUALITIES OF *JUPITER* AND *SATURN*.

BY G. W. HILL.

[Communicated by the Superintendent of the *American Ephemeris and Nautical Almanac*.]

The discussion of the observations of *Jupiter* and *Saturn*, now in progress in the office of the *American Ephemeris and Nautical Almanac*, has reached such a stage that we can exhibit the results in reference to the correction of the mean longitude of *Jupiter* as it is given in my new theory of *Jupiter* and *Saturn*, (*Astronomical Papers of the American Ephemeris*, Vol. IV, p. 588). Dividing the material into eleven groups roughly corresponding to as many revolutions of the planet, values of δL were obtained, which were shown in the following table:

Interval.	Mean Year.	δL.	Weight.
1750–1765	1758	$-0.50 + 0.137a$	4.2
1766–1777	1772	$-0.71 -$ [illegible]7	1.4
1778–1789	1783	$-0.52 - 0.06$[illegible]	0.9
1790–1801	1796	$-1.28 - 0.111a$	2.8
1802–1813	1808	$-1.$[illegible] $+ 0.1$[illegible]	5.5
1814–1825	1820	$-1.$[illegible] $+$ [illegible]4[illegible]	[illegible].1
1826–1837	1832	$+0.01 - 0.007$	11.7
1838–1849	1844	$-0.$[illegible]4 $- 0.$[illegible]98	1[illegible].7
1850–1861	1856	$+0.02 - 0.068$	16.6
1862–1873	1868	$+0.28 + 0.179a$	16.5
1874–1887	1881	$+0.16 + 0.159a$	1[illegible].0

In the values of δL the modifications caused by a change in the mass of *Saturn* are shown by the terms involving a, an indeterminate so chosen that $a = 1$ corresponds to an augmentation of BESSEL's mass by [illegible] part. The column of weights is added that some idea of the degree of precision of the several values of δL may be obtained.

These values can be very well represented by a linear function of the time, with the exception of the three belonging to the interval 1790–1825, which have abnormally large negative values. And the latter cannot be brought into harmony with the rest by assigning to a any possible value; in fact, the solution of the equations gives for a an insignificant quantity.

The disagreement might be attributed to personal equations in the observers; but this seems [illegible] these values of 1796, 1808 and 1820 [illegible] and yet are founded on material [illegible] in the first from Greenwich and Palermo, in the second from Greenwich, Palermo and Paris, and in the third from Greenwich, Paris and Königsberg.

Again we may suppose that there is some inequality of long period in the mean longitude of *Jupiter* not taken into consideration in the theory. If this arises from the mutual action of *Jupiter* and *Saturn*, [illegible] of the latter [illegible] more clearly exhibit the effects of this [illegible]. However, there does [illegible] inequality in *Saturn* two and a half times as large as that which would seem to have [illegible] *Jupiter*.

In order that no [illegible] of this difficulty, I determined to [illegible] great inequalities [illegible] argument [illegible]

[illegible]

As we [illegible]

[illegible]

[illegible] IV, [illegible] 47–46. By [illegible]

We [illegible]

$$+0,0000000038\cos(15g'-6z)+0,0000000132\sin(15g'-6z)$$
$$+0,0000000734\cos(15g'-7z)+0,0000000371\sin(15g'-7z)$$

and, in consequence, the terms

$$-0,0000000111\cos(15g'-6g)+0,0000000136\sin(15g-6g).$$

By means of this expression, we can complete the terms of T and T'' dependent on $5g'-2g$ and its multiples given at pp. 75–91, so that, writing V for $5g'-2g$ they stand as follows:

$$\begin{aligned} T = &-0''.07676841\sin V -0''.18132165\cos V \\ &+0''.0007626\sin 2V -0''.0007509\cos 2V \\ &+0''.0000066\sin 3V +0''.0000079\cos 3V, \\ T' = &+1''.1766033\sin V +2''.7790713\cos V \\ &-0''.0116886\sin 2V +0''.0115086\cos 2V \\ &-0''.000101\sin 3V -0''.000120\cos 3V. \end{aligned}$$

It is evident that, as far as these terms are concerned, with sufficient approximation, we have the equation

$$T + 0.06521557\;T'' = 0.$$

Hence, after the inequalities of *Saturn* have been obtained, it will be only necessary to multiply them by the factor −0.4024 to have those of *Jupiter*. Dealing therefore with *Saturn* alone, we have to consider that V in the expression for T' receives the increment $\delta V = 5n'\delta z' - 2n\delta z$, and thus becomes

$$T' + \frac{dT'}{dV}\delta V + \tfrac{1}{2}\frac{d^2T'}{dV^2}(\delta V)^2.$$

From the expressions of $n\delta z$ and $n'\delta z'$ (*Astr. Papers*, Vol. IV, pp. 103, 119) we get

$$\delta V = 5n'\delta z' - 2n\delta z = -6595''\sin V - 15593''\cos V$$
$$-107.5\sin 2V + 113.2\cos 2V,$$

as also

$$\tfrac{1}{2}(\delta V)^2 = +212''.0\cos 2V + 249''.2\sin 2V.$$

Substituting these values and confining our attention to the terms involving $3V$, we find that T' becomes

$$T' = -0''.002377\sin 3V - 0''.000925\cos 3V.$$

Integrating this twice we get

$$n'\delta z' = +0''.286\sin(3V+21^\circ.3).$$

And, multiplying this by the factor −0.4024,

$$n\delta z = +0''.115\sin(3V+201^\circ.3).$$

It has been assumed here that V will be more correctly denoted by $5g'-2g-82''t$ than by $5g'-2g$, consequently the integrating factor has been taken at 10.58.

The evections associated with these long-period inequalities are not much beneath them in magnitude, and we propose to compute them in the same approximate way.

By induction from the terms involving the six arguments from $7g'-6g$ to $12g'-6g$ in the functions $a'\dfrac{d\Omega'}{dg'}$ and $a'r'\dfrac{d\Omega'}{dr'}$ (*Astr. Papers*, Vol. IV, p. 71) it is found that the latter contain severally the terms

$$a\frac{d\Omega'}{dg'} = +0''.000110\sin(14g'-6g)$$
$$+0''.000176\cos(14g'-6g),$$
$$a'r'\frac{d\Omega'}{dg'} = +0''.000112\cos(14g'-6g)$$
$$-0''.000071\sin(14g'-6g).$$

By means of these additional terms we complete the expression of T', p. 83, so that the terms which involve V now become

$$\begin{aligned} T' = &+2''.50567\sin(-\gamma'+V) -20''.38129\cos(-\gamma'+V) \\ &+0''.10783\sin(-\gamma'+2V) -0''.02865\cos(-\gamma'+2V) \\ &+0''.00039\sin(-\gamma'+3V) +0''.00042\cos(-\gamma'+3V) \end{aligned}$$

Exactly as before, we must now suppose that in T', V receives the increment δV, and thus that T' becomes

$$T' + \frac{dT'}{dV}\delta V + \tfrac{1}{2}\frac{d^2T'}{dV^2}(\delta V)^2.$$

Making the substitution and preserving only the terms involving $3V$, we get

$$T' = +0''.01055\sin(-\gamma'+3V) + 0''.01576\cos(-\gamma'+3V).$$

Integrating this once, making $\gamma' = g'$, and then integrating again, the effect on the coefficients is the same as multiplying them by 11.11, and we obtain

$$n'\delta z' = +0''.212\sin(14g'-6g+55^\circ.6).$$

Proceeding in like manner for *Jupiter* we obtain

$$a\frac{d\Omega}{dg} = +0''.000012\sin(15g'-7g)$$
$$-0''.000012\cos(15g'-7g),$$
$$ar\frac{d\Omega}{dr} = +0''.000011\cos(15g'-7g)$$
$$+0''.000029\sin(15g'-7g).$$

By means of these expressions, we are enabled to add to T terms involving $3V$, so that it now becomes

$$\begin{aligned} T = &-2''.02853\sin(-\gamma+V) +0''.15263\cos(-\gamma+V) \\ &-0''.00484\sin(-\gamma+2V) -0''.00979\cos(-\gamma+2V) \\ &+0''.00003\sin(-\gamma+3V) -0''.00005\cos(-\gamma+3V). \end{aligned}$$

Supposing, in this expression, that V receives the increment δV, it is found that T contains the terms

$$T = +0''.00103\sin(-\gamma+3V) -0''.00131\cos(-\gamma+3V).$$

We then obtain $n\delta z$ by multiplying the coefficients by 25.88 and substituting g for γ. Thus

$$n\delta z = +0''.043\sin(15g'-7g+308^\circ).$$

From induction it is supposed that these two evections will be obtained with greater precision if, in place of $14g'-6g$ and $15g'-7g$, we put $14g'-6g-180''t$ and $15g'-7g-120''t$.

Gathering together our results, the mean longitude of *Jupiter* ought to be increased by the terms

$$n\delta z = +0''.115 \sin(15g'-6g-246''t+201°.3)$$
$$+0''.013 \sin(15g'-7g-120''t+308°),$$

and the mean longitude of *Saturn* by the terms

$$n'\delta z' = +0''.286 \sin(15g'-6g-246''t+21°.3)$$
$$+0''.212 \sin(14g'-6g-180''t+55.6).$$

It will be seen that the long-period inequality for *Jupiter* is not of a magnitude sufficient to remove the difficulty stated at the beginning of this article. However, it appears worth while to have computed these inequalities, if the only result is that the doubt is removed.

Washington, 1891 *Sept*. 26.

COMET 1889 I.

BY E. E. BARNARD.

This comet, which was discovered by me on September 2, 1888, has proved of remarkable interest from the extended duration of its visibility — two years and five days — and from the vast distance to which it was followed. It was an easy object at distance 6.25. In both these peculiarities it by far exceeded any comet previously observed.

I have already called attention to the fact (*A.J.* 245) that the distance to which the comet was carried exceeded that of the aphelia of nearly all of the short-period comets.

In June, 1889, I called attention to what appeared to be an anomalous tail to this comet. Professor BREDICHIN has shown that this was simply an effect of perspective due to the great distance of the comet. I made a number of careful sketches of the position of the tail among the stars during that year, and have communicated these to Professor BREDICHIN, who will have an opportunity to test the phenomenon more thoroughly.

On December 10, 1888, the comet transitted the small bright nebula *N.G.C.* 584, which showed brightly through it slightly south of the nucleus. The following observations were made of the nebula after the observations of the comet, the same comparison-star being used for both objects, — *N.G.C.* 584, ✳22. $\Delta\alpha = +1^m 11^s.87 (6)$, $\Delta\delta = -1' 1''.7 (4)$. From this is deduced the following place for 1888.0:

N.G.C. 584. $\alpha = 1^h 25^m 13^s.86$, $\delta = -7° 26' 42''.4$.

The comet was searched for carefully in 1891, but could not be found with the 36-inch.

The declination in the discovery observation of this comet, as originally published in *A.J.* 182, was in error by one entire revolution of the micrometer-screw (14''.1). I have corrected the observation, and insert it here, having added several extra observations in right-ascension on that date which had been overlooked. I have also inserted here a few other observations from that issue of the *Journal*, in which I have made some slight corrections to the declinations. These corrected values are to be preferred to those published in No. 182.

Observations of the comet made here on six other dates will be found in *A.J.* 182, p. 109.

In following the comet in the fainter stages of its visibility, quite a number of new nebulas were discovered near its path.

Mt. Hamilton, 1891 *September*.

FILAR-MICROMETER OBSERVATIONS OF COMET 1889 I.

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY, BY E. E. BARNARD.

Mt. Hamilton M.T. 1888	✳	No. Comp.	☄ − ✳		☄'s apparent		log $p\Delta$	
			Δα	Δδ	α	δ	for α	for δ
d h m s			m s	' ''	h m s	° ' ''		
Sept. 2 16 22 7	1	10 , 6	+0 58.05	− 7 44.4	6 52 14.14	+10 59 31.2	*n*9.589	0.648
3 16 2 20	2	8 , 6	−1 17.64	− 7 11.5	6 52 10.16	+10 55 43.9	*n*9.617	0.661
4 15 3 4	2	6 , 3	−1 22.76	−10 55.4	6 52 5.03	+10 52 0.7	*n*9.659	0.686
4 15 57 38	3	16 , 4	−2 42.68	+ 4 55.4	6 52 5.24	+10 51 48.8	*n*9.643	0.658
12 15 43 48	5	7 , 5	+0 17.32	+11 22.9	6 50 34.34	+10 17 26.1	*n*9.589	0.653
16 15 31 9	5	8 , 5	−1 6.56	− 8 2.9	6 49 10.56	+ 9 58 0.4	*n*9.574	0.653
17 16 20 11	6	12 , 6	−0 19.58	+ 5 15.3	6 48 44.09	+ 9 52 44.9	*n*9.480	0.654
17 16 45 41	5	4 , 3	−1 33.43	−13 24.6	6 48 43.73	+ 9 52 38.7	*n*9.408	0.626
25 16 24 41	7	5 , 7	+1 19.58	+ 7 49.4	6 43 57.78	+ 9 7 13.7	*n*9.364	0.633
26 16 36 3	7	8 , 6	+0 32.35	+ 1 36.5	6 43 10.58	+ 9 1 0.8	*n*9.342	0.633
27 16 34 34	7	8 , 6	−0 18.08	− 4 51.5	6 42 20.19	+ 8 54 32.8	*n*9.292	0.630
28 16 22 47	8	8 , 7	+1 0.69	+ 5 42.4	6 41 28.38	+ 8 48 0.1	*n*9.316	0.632
Oct. 7 14 41 32	9	8 , 6	+2 16.75	+ 1 52.4	6 31 0.67	+ 7 41 26.1	*n*9.483	0.660
8 17 8 31	9	4 , 3	+0 37.01	− 7 29.6	6 29 20.98	+ 7 32 4.1	*n*8.476	0.640

Mt. Hamilton M.T. 1888		*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log p Δ for α	log p Δ for δ
	d h m s			m s	′ ″	h m s	° ′ ″		
Oct.	9 13 5 1	10	10	+1 10.03	0 0.0	6 28 2.58	+ 7 21 29.1	n8.011	0.641
	10 17 1 10	10	12 , 6	—0 16.16	—10 23.2	6 26 6.40	+ 7 11 5.9	n8.041	0.642
	15 17 21 51	11	8	. . . .	— 5 41.7	. . . .	+ 6 25.5	. .	0.654
	15 17 32 11	11	8	+0 55.39	. . . . .	6 16 21.6	. . . .	9.041	. . .
	21 11 53 17	12	8 , 6	—1 55.28	+ 1 35.7	5 52 50.14	+ 4 40 15.4	n9.593	0.693
	26 12 15 33	13	. . .	. . . .	0 0.0	. . . .	+ 4 11 56.6	9.	0.678
	26 12 56 11	13	11	+0 49.54	. . . . .	5 45 47.06	. . . .	n9.411	. . .
	27 12 36 57	14	8 , 6	+0 11.36	+ 1 36.5	5 12 18.81	+ 3 57 20.4	n9.473	0.678
	29 11 38 31	15	8 , 6	—2 16.04	— 3 20.3	5 31 45.72	+ 3 27 20.0	n9.558	0.688
	31 17 37 46	16	6 , 6	—0 34.08	+ 5 45.4	5 25 18.34	+ 2 50 32.0	9.512	0.685
Nov.	6 16 19 30	17	3	. . . .	+ 3 16.0	. . . .	+ 1 3 12.3	. . .	0.687
	6 16 32 56	17	8	+1 49.00	. . . . .	4 56 3.70	. . . .	9.493	. . .
	18 9 57 18	18	10 , 8	+0 2.38	— 0 16.7	3 12 11.68	— 2 54 49.1	n9.502	0.750
	20 9 41 20	19	10 , 6	—0 29.89	+ 2 21.4	3 28 20.31	— 3 33 36.8	n9.322	0.757
	24 10 59 28	20	8 , 7	+1 23.44	— 0 28.7	3 0 1.91	— 4 46 8.4	8.568	0.769
Dec.	2 10 7 30	21	6 , 6	+0 20.65	— 0 56.1	2 8 2.31	— 6 32 10.7	9.013	0.785
	10 8 33 38	22	6	+2 1.65	. . . . .	1 25 33.15	. . . .	8.778	. . .
	10 8 15 55	22	4	. . . .	— 0 41.8	. . . .	— 7 26 11.3	. . .	0.792
	11 8 5 33	23	8 , 6	+2 17.77	— 0 8.8	1 21 2.93	— 7 29 57.7	8.322	0.794
1889 Jan.	11 7 48 51	24	4 , 7	—2 42.09	+ 0 11.4	0 2 3.53	— 6 39 26.3	9.551	0.767
Apr.	28 16 6 28	25	0 , 2	. . . .	— 0 24.2	. . . .	+ 1 22 49.6	. .	0.726
May	9 15 45 39	26	6 , 5	+0 52.01	— 1 33.7	23 19 48.39	+ 1 58 17.1	9.629	0.719
June	2 11 22 52	27	12 , 3	—0 3.70	+ 2 3.1	22 51 58.18	+ 2 40 7.1	9.587	0.711
	8 15 15 9	28	6 , 4	—1 7.84	— 0 0.7	22 41 4.71	+ 2 38 16.6	9.413	0.705
	22 13 2 37	29	8 , 6	+1 27.61	— 6 27.6	22 8 8.57	+ 2 4 51.7	9.517	0.712
	30 11 10 30	30	8 , 6	—2 8.86	— 0 2.1	21 44 20.79	+ 1 23 34.1	n9.603	0.719
July	7 15 48 15	31	6 , 5	—0 46.40	— 6 42.8	21 20 3.26	+ 0 31 20.1	9.276	0.722
	16 11 36 51	32	12 , 6	—2 24.20	— 2 56.1	20 48 5.30	— 0 49 56.9	n9.255	0.733
Aug.	6 14 23 3	33	10	—0 9.49	— 0 2.6	19 35 48.76	— 4 32 42.7	9.602	0.749
	27 9 28 55	34	10 , 6	+0 26.11	+ 1 16.2	18 17 31 02	— 7 35 25.1	9.140	0.792
Sept.	22 7 18 59	35	10 , 6	+1 31.52	+ 5 5.6	18 19 23.98	—10 4 16.1	9.297	0.806
	23 8 23 56	35	2 , 3	+0 56.55	+ 0 34.7	18 18 49.01	—10 8 47.1	9.512	0.806
	26 8 2 29	36	10 . 6	+0 25.11	— 5 3.3	18 17 20.54	—10 21 19.0	9.408	0.799
Oct.	15 6 57 4	37	12 , 6	—0 34.39	— 4 37.5	18 13 8.85	—11 24 25.1	9.147	0.803
Nov.	11 7 13 36	38	10 , 4	+1 20.50	+ 2 7.1	18 18 28.64	—12 19 4.4	9.649	0.761
	15 7 9 41	38	8 , 5	+1 41.06	+ 1 5.0	18 18 49.19	—12 20 6.7	9.649	0.762
1890 May	15 14 50 21	39	4 , 4	+2 20.62	+11 4.2	18 18 34.87	— 7 21 56.6	8.279	0.792
	16 13 59 15	40	12 , 6	—0 27.17	— 6 39.5	18 17 36.86	— 7 20 28.1	n8.903	0.792
	20 13 52 58	41	4	. . . .	+ 0 59.6	. . . .	— 7 14 26.2	. . .	0.762
	20 14 16 42	41	12	+2 13.98	. . . . .	18 13 28.69	. . . .	0.000	. . .
June	6 11 14 44	42	8 , 3	+0 50.98	+ 1 26.3	17 54 53.40	— 6 56 39.0	n9.292	0.783
	10 12 51 26	43	8 , 3	—3 6.47	— 3 40.9	17 50 17.72	— 6 54 27.2	8.672	0.787
	16 12 59 34	44	2	. . . .	+ 0 44.3	. . . .	— 6 52 41.7	. . .	0.786
	16 13 9 14	44	3*	—0 8.00	. . . . .	17 43 28.71	. . . .	9.149	. . .
July	13 11 9 44	45	14 , 6	—0 50.31	— 6 14.5	17 16 19.59	— 7 6 1.7	9.220	0.787
	14 10 11 27	45	20 , 5	—1 41.69	— 7 26.3	17 15 28.22	— 7 7 13.4	9.090	0.788
	15 10 22 28	45	3	. . . .	— 8 31.0	. . . .	— 7 8 18.2	. . .	0.789
	15 10 46 27	45	12	—2 33.12	. . . . .	17 14 36.79	. . . .	9.139	. . .
Aug.	7 9 22 33	46	5	. . . .	+ 1 34.2	. . . .	— 7 43 53.4	. . .	0.790
	7 9 45 4	46	4*	—0 13.30	. . . . .	16 58 55.91	. . . .	9.350	. . .
	11 8 56 30	47	2	. . . .	+ 0 40.1	. . . .	— 7 52 19.2	. . .	0.792
	11 9 12 33	47	3*	—0 5.88	. . . . .	16 56 59.02	. . . .	9.297	. . .
	17 8 59 3	48	5	. . . .	+ 4 10.2	. . . .	— 8 2 51.7	. . .	0.790
	17 9 11 2	48	5*	+0 3.92	. . . . .	16 54 22.37	. . . .	9.297	. . .
Sept.	7 8 15 21	49	5	+0 0.23	— 2 42.3	16 49 27.9	— 8 46.8	9.474	0.787

* Δα measured direct.

The observations of 1890 August 17 and September 7, made with 36-inch.

Mean Places for 1888, 1889, 1890.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	6 51 15.53	+0.56	+11 7 16.6	− 1.0	Compared with Schjellerup 2131
2	6 53 27.23	+0.57 +0.60	+11 2 56.7	− 0.9 − 0.8	Compared with * 1
3	6 54 47.32	+0.60	+10 46 51.2	− 0.8	⅓(2 Arm.₂ 841 + W.B. VI. 1628)
5	6 50 16.19	+0.83 +0.94 +0.97	+10 6 3.8	− 0.6 − 0.5 − 0.5	B.B. VI. 10° 1335
6	6 49 2.71	+0.97	+ 9 47 27.0	− 0.1	W.B. VI. 1437
7	6 42 36.97	+1.23 +1.26 +1.30	+ 8 59 21.4	− 0.1 − 0.1 − 0.1	⅓(2 Glas: + W.B. VI. 1251)
8	6 40 26.35	+1.34	+ 8 42 17.9	+ 0.1	W.B. VI. 1164
9	6 28 42.28	+1.64 +1.69	+ 7 39 33.1	+ 0.6 + 0.6	Ll. 12601
10	6 26 50.81	+1.74 +1.75	+ 7 24 28.5	+ 0.6 + 0.6	Ll. 12540
11	6 15 24.4	+1.80	+ 6 31.2	+ 0.7	DM. +6° 1208
12	5 54 43.41	+2.28	+ 4 38 37.7	+ 2.0	Ll. 11583
13	5 44 55.16	+2.36	+ 4 11 54.3	+ 2.3	W.B. IV. 1101
14	5 42 5.05	+2.40	+ 3 55 41.2	+ 2.7	Albany A.G. 1897
15	5 36 59.28	+2.48	+ 3 30 47.3	+ 3.0	Albany A.G. 1863
16	5 25 49.87	+2.55	+ 2 44 43.1	+ 3.5	Albany A.G. 1787
17	4 54 11.94	+2.76	+ 0 59 51.6	+ 4.7	W.B. IV. 1118
18	3 42 6.54	+2.76	− 2 51 39.5	+ 7.1	W.B. III. 771
19	3 28 47.37	+2.83	− 3 36 9.2	+ 8.0	W.B. III. 491
20	2 58 35.53	+2.94	− 4 45 48.0	+ 8.3	W.B. II. 1003
21	2 7 38.91	+2.75	− 6 31 22.5	+ 7.9	W.B. II, 77
22	1 23 28.99	+2.51	− 7 25 37.7	+ 8.2	Bonn Obs.
23	1 18 42.68	+2.48	− 7 29 58.1	+ 9.5	W.B. I. 271
1889 24	0 0 44.36	+1.26	− 6 39 26.6	−11.1	Schjellerup 29
25	23 28 43.02	−0.91	+ 1 23 24.0	−10.2	W.B. XXIII. 511
26	23 18 55.77	+0.61	+ 2 0 1.8	−10.9	Albany A.G. 8070
27	22 52 1.61	+0.27	+ 2 38 5.0	− 1.0	Albany A.G. 7925
28	22 42 12.06	+0.19	+ 2 38 15.1	+ 1.9	De Ball 358
29	22 6 39.84	+1.12	+ 2 11 17.7	+ 1.6	W.B. XXII. 85
30*	21 46 28.18	+1.47	+ 1 23 30.5	+ 5.7	⅓(Lam. 8582 + 2 Albany A.G. 7631)
31	21 20 47.85	+1.81	+ 0 37 56.2	+ 6.7	W.B. XXI. 433
32	20 50 27.54	+1.96	− 0 47 8.9	+ 8.1	W.B. XX. 1241
33	19 35 56.11	+2.11	− 4 32 19.2	+ 9.1	Schjellerup 7525
34	18 47 3.01	+1.87	− 7 36 51.1	+ 9.8	½(W.B. XVIII. 1143 + Y. 8165)
35	18 17 51.10	+1.36	−10 9 27.6	+ 5.9	Compared with Schjellerup 6694
36	18 16 51.05	+1.38	−10 16 20.9	+ 5.2	⅓(W.B.XVIII. 325 + Schj. 6694 + Gould 25067)
37	18 13 41.35	+1.89	−11 19 52.8	+ 5.2	½(Ll. 33712 + Lam. 2366)
38	18 17 5.31	+2.80	−12 21 15.0	+ 3.5	Schjellerup 6696
1890 39	18 16 13.19	+1.06	− 7 32 57.2	− 3.6	Schjellerup 6690
40	18 18 2.87	+1.16	− 7 13 15.2	− 3.4	Compared with W.B. XVIII. 372
41	18 11 13.09	+1.62	− 7 15 23.8	− 2.0	W.B. XVIII. 184
42	17 51 0.80	+1.62	− 6 58 3.1	− 1.7	W.B. XVII. 1071
43	17 53 22.57	+1.66	− 6 50 11.6	− 1.7	Σ 2250 s.f. component
44	17 13 31.96	+1.75	− 6 53 21.8	− 1.2	10" compared with Schjellerup 6414
45	17 17 8.06	+1.84 +1.85 +1.85	− 6 59 17.3	+ 0.1 + 0.2 + 0.1	½(Schj. 6203 + Lam. 2369) Schj. cor. −1
46	16 59 7.60	+1.61	− 7 15 28.1	+ 0.5	10" compared with W.B. XVI. 1067
47	16 57 3.31	+1.59	− 7 52 59.9	+ 0.6	Compared with * 46
48	16 54 16.98	+1.17	− 8 7 2.5	+ 0.6	10" comp. with ½(W.B. XVI. 975 + Lam. 2309)
49	16 19 26.6	+1.13	− 8 11.1	+ 0.6	SDM − 8 4351

* Proper motion applied. The Bessel place rejected because of discordance in right-ascension

STAR COMPARISONS.

	$\Delta\alpha$	c	$\Delta\delta$	c	
	m s		′ ″		
✱ 1 Schj. 2134	$+1\ 23.25$	8	$+\ 2\ 35.2$	1	
✱ 2 = ✱ 1	$+2\ 11.70$	6	$-\ 4\ 19.6$	2	
✱ 35 Schj. 6691	$+0\ 51.10$	8	$+\ 6\ 51.8$	1	
✱ 10 W.B. XVIII, 372	$-0\ 11.75$	6	$-\ 5\ 16.6$	3	
✱ 11 Schj. 6114	$-2\ \ 2.01$	6	$-\ 3\ 28.4$	3	
✱ 16 — W.B. XVI, 1067	$+0\ 33.69$	11	$-12\ 24.8$	6	
✱ 17 — ✱ 16	$-2\ \ 1.29$	12	$-\ 7\ 31.8$	3	
✱ 18 — ½(W.B. XVI, 975 + Lam. 2309)	$+0\ 11.99$	20	$-19\ 43.2$	7	2 nights
✱ 18 — Lam. 2323	$-2\ 18.66$	12	$-\ 0\ 51.8$	7	2 nights

From these observations, the star Lamont 2323 gives the right-ascension of the 10^M star 4s about 1^s less than does the star Bessel XVI, 975+Lam. 2309. It would appear, if there is no proper motion, that the star Lam. 2323 needs a correction of $+1^s$, since the Bessel and Lamont observations of the other star are not very discordant.

In comparing star 18 with the Bessel-Lamont star, an intermediate star SDM. $-7°$ 4383 was used. For this the observations give

	$\Delta\alpha$	c	$\Delta\delta$	c	
DM $-7°$ 4383 $-$ ½(W.B.+Lam.) =	$-0^m\ 7^s.01$	20	$-12'\ 30''.9$	7	2 nights.

The resulting place for 1890.0 being $\alpha = 16^h\ 53^m\ 27^s.98$, $\delta = -7°\ 59'\ 50''.3$.

OBSERVATIONS OF β *DELPHINI*, τ *CYGNI* AND ζ *URSAE MAJORIS*,

BY A. HALL.

[Communicated by Capt. F. V. McNAIR, U.S.N., Superintendent.]

In closing my observations of double stars, I have examined some of the close pairs recently discovered, and the following measures may be of interest.

β Delphini.

	p	s
	°	″
1891.609	328.4	0.41
1.642	331.9	0.34
1.686	329.9	0.42
1891.646	330.07	0.390

τ Cygni.

	p	s
1891.686	9.8	0.62
1.692	8.8	0.44
1.711	9.2	0.50
1891.696	9.27	0.520

β Delphini was discovered by S. W. BURNHAM, and *τ Cygni* by A. G. CLARK. On account of the magnitudes of the components the first is now the easier pair. During the above observations *τ Cygni* was always blazing, and the companion being small it is a difficult object. The distance and angle of this pair have both diminished. The change of the angle is 138° since 1879.

The star *ζ Ursae Majoris* has been photographed several times, and the angle and distance have been determined in this way. For the sake of comparison I add my measures of this wide pair.

ζ Ursae Majoris.

	p	s
	°	″
1885.424	148.0	14.57
5.426	147.8	14.44
5.430	149.5	14.55
5.441	148.1	14.56
5.452	148.9	14.50
1885.435	148.46	14.524

The assumption made by BOND and others that the photographic determinations are free from constant errors is, I think, doubtful. This is a point that needs examination. It would also be interesting to have an estimate of the relative amount of work by the two methods.

Naval Observatory.

OBSERVATIONS OF WOLF'S COMET.

MADE AT THE OBSERVATORY OF THE STATE UNIVERSITY OF MISSOURI.

BY MILTON UPDEGRAFF.

1891 Columbia M.T.	*	No. Comp.	☄ − * $\Delta\alpha$	☄ − * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ α	log $p\Delta$ δ
d h m s			m s	′ ″	h m s	° ′ ″		
Sept. 4 14 53 23.4	1	8	+2 3.74	−3 27.6	3 41 25.71	+23 58 18.5	*n*9.3706	0.4117
6 14 42 38.1	2	8	+2 26.59	+1 57.0	3 45 43.56	+23 24 51.8	*n*9.3936	0.4307
8 14 53 16.5	3	3	−0 42.82	−2 46.6	3 49 55.00	+22 18 53.2	*n*9.3400	0.4512
10 15 31 15.1	4	8	+3 36.11	+0 42.5	3 54 3.53	+22 10 12.3	*n*9.1036	0.4172
11 15 0 35.4	5	3	−2 16.88	+4 12.4	3 55 59.94	+21 51 25.9	*n*9.2823	0.4125
12 14 51 3.5	6	10	−0 7.75	+2 5.4	3 57 54.0	+21 31.8	*n*9.3012	0.4524
13 15 22 20.5	7	10	−1 55.13	−5 43.5	3 59 51.0	+21 11.0	*n*9.1408	0.4423

Mean Places for 1891.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 39 20.30	+1.70	+24 1 37.6	+8.49	½(W.B.+Yarnall)
2	3 43 15.24	+1.73	+23 22 46.0	+8.78	Yarnall
3	3 50 36.07	+1.75	+22 51 30.9	+8.92	⅓(W.B.+Yarnall+Glasgow)
4	3 50 25.57	+1.82	+22 9 50.1	+9.36	Glasgow
5	3 58 14.97	+1.82	+21 47 4.1	+9.42	Glasgow
6	3 57 59.9	+1.85	+21 29.5	+9.64	DM. +21° 583
7	4 1 44.2	+1.87	+21 16.5	+9.76	DM. +21° 592

In making the above observations the instruments used were the 7½-inch equatorial telescope and filar micrometer of this observatory, by MERZ and MAHLER, and a sidereal clock and chronograph, both by FAUTH & Co. The comparisons secured on Sept. 8 and 11 were not entirely satisfactory, the comet being faintly visible through light clouds, which finally interrupted the observations.

The position of the observatory is approximately,

$\lambda = 6^h\ 9^m\ 18^s$ W. from Greenwich, and $\varphi = +38°\ 56'\ 50''$.

EPHEMERIS OF WOLF'S PERIODIC COMET *1884 III*.

BY WILLIAM BELLAMY.

(Continued from page 45.)

Gr. M.T.	App. α	App. δ	log Δ
1891	h m s	° ′ ″	
Dec. 12.5	4 18 16.29	−14 40 23.4	0.00683
13.5	17 50.44	14 43 37.8	
14.5	17 25.99	14 46 17.5	0.01458
15.5	17 2.97	14 48 23.6	
16.5	16 41.41	14 49 55.3	0.02244
17.5	16 21.33	14 50 55.1	
18.5	16 2.77	14 51 23.1	0.03040
19.5	15 45.71	14 51 21.0	
20.5	15 30.28	14 50 48.8	0.03845
21.5	15 16.40	14 49 47.7	
22.5	4 15 4.12	−14 48 18.6	0.04658
Dec. 23.5	4 14 53.17	−14 46 22.2	
24.5	14 44.45	14 43 59.3	0.05476
25.5	14 37.08	14 41 10.9	
26.5	14 31.38	14 37 57.8	0.06300
27.5	14 27.36	14 34 20.7	
28.5	14 25.02	14 30 20.6	0.07127
29.5	14 24.37	14 25 58.3	
30.5	14 25.42	14 21 14.7	0.07958
31.5	14 28.16	14 16 10.5	
32.5	4 14 32.60	−14 10 46.4	0.08790

OBSERVATIONS OF COMET *d* 1891 (*BARNARD, Sept. 27*),

MADE WITH THE 15-INCH EQUATORIAL OF THE HARVARD COLLEGE OBSERVATORY,

By O. C. WENDELL, Assistant.

[Communicated by Professor Edward C. Pickering, Director.]

1891 Cambridge M.T.	✳	No. Comp.	☄ — ✳ Δα	☄ — ✳ Δδ	☄ apparent α	☄ apparent δ	log pΔ for α	log pΔ for δ
d h m s			m s	′ ″	h m s	° ′ ″		
Sept. 30 10 32 11	1	6	—1 6.71	—7 44.9	20 53 6.97	—1 3 37.4	9.389	0.781
Oct. 1 9 42 25	2	11	—0 30.21	—3 20.3	20 52 53.46	—0 53 52.1	9.231	0.780
2 8 57 6	3	8	—0 38.61	+6 41.6	20 52 45.07	—0 43 50.2	8.973	0.779
3 9 25 44	4	9	—0 11.20	+5 19.6	20 52 40.18	—0 32 57.3	9.190	0.778

Mean Places for 1891.0 of Comparison-Stars.

✳	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	20 51 11.56	+2.12	—0 56 2.6	+10.1	7 comps. with W. Bessel XX, 1315
2	20 53 21.60	+2.10	—0 50 11.9	+10.1	W. Bessel, XX, 1315
3	20 53 21.60	+2.08	—0 50 11.9	+10.1	W. Bessel, XX, 1315
4	20 53 22.32	+2.06	—0 38 57.0	+10.1	W. Bessel, XX, 1317

JUPITER'S FIRST SATELLITE.

A telegraphic dispatch of Sept. 28 from Prof. Holden states, "that the observations of Prof. Schaeberle and Prof. Campbell during August and September, show that the first satellite of *Jupiter* is ellipsoidal, and that one of its longer axes is directed towards the center of *Jupiter*. The other satellite appears to be spherical."

COMET *d* 1891.

A comet was discovered by Prof. Barnard at the Lick Observatory on Sept. 27 in the following position:

1891 Sept. 28.6986 Green. M.T., $\alpha = 20^h\ 53^m\ 45^s.4$, $\delta = -1^\circ\ 22'\ 36''$. Motion north preceding.

Later observations have been obtained by Mr. Wendell, and have been communicated in full below. He describes the comet as extremely faint, estimating its brightness as equivalent to that of a star of the 13.5 magnitude.

COMET *e* 1891.

A bright comet was discovered by Prof. Barnard in the following position:

1891 Oct. 3.042 Greenw. M.T., $\alpha = 7^h\ 31^m\ 24^s$, $\delta = -27^\circ\ 54'$ Motion south following.

The following orbit, telegraphically communicated by Prof. Holden, was computed by Prof. Campbell, now of the Lick Observatory, from observations there on Oct. 3, 4 and 5.

Elements.

$T = 1891$ Nov. 8.75 Gr. M.T.

$$\left.\begin{array}{l}\omega = 262^\circ\ \ 6' \\ \Omega = 215\ \ \ 38 \\ i = \ \ 75\ \ \ 50\end{array}\right\}1891.0$$

$q = 1.0166$

Ephemeris.

Greenw. M.T.	α	δ	Brightness
	h m s	° ′	
Oct. 6.5	7 52 0	—32 52	1.05
10.5	8 18 0	38 18	
14.5	8 46 20	43 8	
18.5	9 16 44	—47 14	1.05

NEW ASTEROID.

An asteroid of the thirteenth magnitude was discovered by Charlois, at Nice, as follows:

1891 Sept. 24.3087, $\alpha = 21^h\ 23^m\ 3^s.5$, $\delta = -12^\circ\ 19'\ 40''$. Daily motion -16^s in α, and 4′ southward.

CONTENTS.

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ON ECLIPSES AND CHRONOLOGY.

BY JOHN N. STOCKWELL.

1. In numbers 240, 241 and 244, of this Journal, I have endeavored to rectify some of the principal dates of chronology by means of ancient eclipses. Since the publication of these numbers of the Journal I have obtained some additional historical facts, which confirm, in the most satisfactory manner, all the conclusions previously arrived at. I now propose to show how these new facts confirm the old; and also to reply to the criticism of Mr. Lynn, which appeared in number 246.

2. There are a number of ancient eclipses mentioned by historians, in which the descriptions given are sufficiently precise to serve as a test of the accuracy of the astronomical theories on which the calculations are based, when the date of the eclipse has once been correctly determined. I shall first give the results of the calculations of such eclipses, as a verification of the correctness of my theory of eclipses; and shall then apply the theory to the discussion of historical traditions whose chronology can be determined only by means of such calculations.

3. As a first example, I find in Johnson's *Eclipses, Past and Future*, the following description of an eclipse of the sun, observed at Constantinople A.D. 418 July 19. The description is from Philostorgius (XII, 8) who says, that "on July 19, towards the *eighth hour* of the day, the sun was so eclipsed that the stars were even visible." Johnson then states that according to his own calculations, the greatest eclipse at Constantinople occurred at $12^h 39^m$ noon, at which time there was a thin crescent uncovered on the sun's northern limb; thus showing that the line of totality passed a little southward of that place. But according to my own calculation, the time of greatest eclipse at Constantinople was at $2^h 7^m$ in the afternoon; and the magnitude of the eclipse at that time was *eleven digits* on the sun's southern limb. The *calculated time* of the eclipse thus agrees perfectly with the statement of Philostorgius, while the *time*, as calculated by Johnson, was more than an hour too early in the day.

As a second example I take the eclipse of Pelopidas, which occurred B.C. 364 July 13. During the war between Alexander of Pherae, and Thessaly, Pelopidas of Thebes was requested to succor the Thessalians; and Plutarch in his *Life of Pelopidas*, makes the following statement in regard to an eclipse of the sun, which took place at that time. He says, "The Thebans willingly granted their desire; and now when all things were prepared, and the general beginning to march, the sun was eclipsed, and darkness spread over the city of Thebes at noonday."

According to Johnson's computation the eclipse took place at Thebes about $8^h 45^m$ in the morning, which is certainly a long time before noon; but my own computation gives $11^h 40^m$ as the time of greatest eclipse at Thebes; and this agrees perfectly with the statement of the historian.

Plutarch in his *Dissertation on the Lunar Spots*, alludes to an eclipse of the sun which had *recently* happened about *mid-day*. The darkness was so great as to cause the day to resemble night; and stars were everywhere visible. This eclipse is referred to by Grant in his *History of Physical Astronomy*; and also by Johnson in *Eclipses, Past and Future*. Johnson says its date is very hard to determine; but he finally concludes that an eclipse which occurred A.D. 83 July 27, accords sufficiently well with the description to justify the belief that it was really the one referred to. Grant does not give any date, but concludes that it must have taken place at some time antecedent to September, A.D. 96. The illustrious Kepler computed a great number of eclipses that occurred about the close of the first century, and finally concluded that an eclipse which took place June 1, A.D. 113, accorded with the description better than any other.

I have, therefore, computed both these eclipses, and have obtained the following results:

The eclipse of Dec. 27, A.D. 83, was central and total at noon in longitude 13° 37′ west of Greenwich, and latitude 23° 1′ north. The greatest eclipse at Rome was at $2^h 49^m$, local mean time, in the afternoon; and its magnitude was a little more than *eight digits* on the sun's southern limb. The latitude of the shadow when nearest to Rome was 27° 21′ north; and it was not total anywhere in the Roman Empire, unless it was in Egypt, where it took place near sunset. The time of day at which it occurred is sufficient to preclude its being the one mentioned by the historian.

The eclipse of June 1, A.D. 113, was central and total at noon in longitude 18° 20′ east of Greenwich, and latitude 51° 11′ north. The time of greatest eclipse at Rome was at $11^h\ 27^m$ local apparent time on the morning of June 1. Its magnitude at Rome was nearly eight and one-half digits on the sun's northern limb; which is very nearly the same as in the other eclipse. This eclipse, however, was total throughout the northern part of the Roman Empire; and the time of day at which it took place agrees well with the statement of Plutarch, who says that it occurred about noon. This was the only large eclipse of the sun which was visible at Rome within two hours of noon, since the eclipse of November 24, A.D. 29, — a period of eighty-four years. It occurred about the middle of the day: and was total far south of the northern boundary of the Roman Empire; but it was not total at Rome: nor does Plutarch say that it was. I think, therefore, there can be very little doubt that this is the eclipse to which Plutarch refers.

4. We shall now consider the date of the eclipse of Ennius and of the *founding of Rome*.

Hansen has computed the eclipse of B.C. 400, June 21, which he has supposed to be the eclipse mentioned by Ennius; the tradition of which is given by Cicero in his *De Republica* (I. 16). His investigation is in his *Darlegung*, published in 1864. According to Hansen's computation, the sun was totally eclipsed at Rome about five minutes before sunset on the above date; and since Ennius states that it occurred 350 years after the founding of Rome, it would follow that Rome was founded in the year B.C. 750. But according to my computation the above eclipse was central and total at noon in longitude 111° 28′ west of Greenwich, and latitude 65° 18′ north; and the central eclipse left the earth in longitude 13° 15′ west of Greenwich, and latitude 44° 27′ north. The sun therefore set at Rome $1^h\ 46^m$ before the central eclipse ended: and the eclipse was wholly invisible at Rome. The eclipse of B.C. 400, June 21, was, therefore, not the one referred to by Ennius.

Having shown that the eclipse of B.C. 400 could not be the one to which Ennius referred, we must seek for another to take its place. If we extend our search backwards to the year B.C. 404, we shall find that there was a very large eclipse visible at Rome on the morning of September 3 of that year. I find by computation that there was an annular eclipse at that date: and that the sun was centrally eclipsed at noon in longitude 47° 48′ east of Greenwich, and in latitude 39° 44′ north. The time of greatest eclipse at Rome was $8^h\ 34^m$ on the morning of Sept. 3: at which time the magnitude of the eclipse was *ten digits*.

Now since Rome was founded 350 years before this eclipse, it follows that it was founded in the year B.C. 754. Moreover, according to Varro, Rome was founded in the third year of the sixth Olympiad, or *twenty-three* years after the first Olympiad; from which it follows that the first Olympiad was celebrated in the year B.C. 777; and this agrees exactly with the date derived from the eclipse of Xerxes, which took place *seventy-seven* years earlier. Ennius speaks of the eclipse as having taken place on the *nones* of June; hence it follows that the Roman calendar was then about three months in error. I think we may therefore now consider the date of the eclipse of Ennius as satisfactorily determined.

5. We may also prove that the first Olympiad was celebrated in the year B.C. 777, by means of the history of Alexander the Great. For it is well known that the great battle of Arbela, between Alexander and Darius Codomannus, occurred eleven days after a total eclipse of the moon. Now I find that the middle of that eclipse took place at *eleven* o'clock, Arbela mean time, on the night of September 20, of the year B.C. 331; and Rollin, the historian, informs us in his history of Alexander, that the death of Darius, which took place in the following winter, occurred in the *third year* of the 112th Olympiad. Now since the olympic years commence with July, it is evident that the death of Darius occurred in the same olympic year as the battle of Arbela. But the third year of the 112th Olympiad would be just 416 years after the first Olympiad; and hence the first Olympiad occurred in the year B.C. (331 + 416) = B.C. 777.

6. In number 240 of this Journal, I have shown from the events associated with Caesar's Spanish War, that Caesar must have been assassinated in March, B.C. 45, instead of B.C. 44, as usually given by historians. But there are other circumstances connected with the event itself which throw additional light upon the date of its occurrence; and these circumstances confirm the conclusions already reached, in the most satisfactory manner.

Plutarch, in his *Life of Caesar*, speaks of the events which took place during the night preceding the assassination as follows: "After this, as he was in bed with his wife, all the doors and windows of the house flew open together; he was startled at the noise, and the light which broke into the room, and sat up in his bed, where by the *light of the moon* he perceived Calpurnia fast asleep, but heard her utter in her dream some indistinct words and inarticulate groans. She fancied at that time she was weeping over Caesar, and holding him butchered in her arms . . . ." And Seyffarth, after a more extended examination of ancient writers states the case thus, in his *Chronology*, &c., page 161. "The historians furthermore relate that on the night preceding Caesar's assassination, on the fifteenth of March, Calpurnia, Caesar's wife, was awakened by the light of the full moon."

Now, although these accounts differ somewhat as to particulars, they both agree in the important fact that the light of the moon played an important part in the affairs of the moment: and it would therefore appear that the moon was very near the full on the night of the fourteenth of March which preceded Caesar's death. Now in B.C. 44 there was a full moon on March 4; and consequently on March 14, it

would lack only about five days of being new moon again. But in B.C. 45, there was a full moon on March 15, at nine o'clock in the morning, mean time at Rome. Therefore, if the ancient narratives are to be depended upon, Caesar must have been assassinated in the year B.C. 45. Now, according to Seyffarth, the Olympic games were celebrated in the July following Caesar's death; they were therefore celebrated in the year B.C. 45. This date agrees exactly with that derived from the Spanish War; and also fixes the celebration of the Olympic games to the bissextile years of the Julian calendar. It also confirms the statements of the chronologist Julius Africanus and Censorinus; as well as the conclusions which I have deduced from the eclipses of Xerxes, Ennius and Arbela. It therefore seems to me there can no longer be any doubt that Caesar was assassinated on March 15 in the year B.C. 45; and that all the dates of the early Roman empire should be placed one year earlier in chronology.

7. It now only remains to notice briefly the criticism of Mr. Lynn, which appeared in number 246 of this Journal. The only really important point to which he has called attention occurs in § 2; and I am surprised that he should call attention to the fact that the year of the Olympiads was not mentioned by Josephus; inasmuch as I had already done so in number 240 of this Journal. But Mr. Lynn represents me as stating that Josephus says that Jerusalem was taken by Pompey in the *first year* of the one hundred and seventy-ninth Olympiad; whereas the contrary is what I said, as he will readily see by reference to my paper. The case stands thus; Josephus tells us that Jerusalem was captured by Pompey in the one hundred and seventy-ninth Olympiad, and by Herod in the one hundred and eighty-fifth Olympiad, without telling us the particular years of the quadrennial periods in which they occurred; but he makes the further statement that the interval between the two events was just twenty-seven years. Now this could not possibly happen unless the captures were made in the first year the one hundred and seventy-ninth Olympiad, and the fourth year of the one hundred and eighty-fifth Olympiad. For, if the first capture was in the second year of the Olympiad, twenty-seven years would bring the second capture to the first year of the one hundred and eighty-sixth Olympiad; and, consequently, would not tally at all with the statement of Josephus.

Mr. Lynn's statement that Suetonius is a better historical authority than Josephus is, perhaps, correct; but the credibility of a historian is measured by the fidelity with which his statements correspond with facts which can be independently determined; and in the present instance the greater merit should unquestionably be accorded to Josephus.

In regard to the Spanish war nothing more need be said. The fact that there was a full moon at the time of Caesar's death, fixes the year of its occurrence and corroborates the usual interpretation of the narrative of the Spanish war. And as to the date of the battle of *Pydna*, it seems to me that the astronomical evidence is wholly in favor of the year B.C. 172. The change of its date by four years is just the same as that of the eclipse of Ennius, and less than one-quarter of the change in the date of the eclipse of Thales.

Cleveland, Ohio, 1891 *October* 28.

ON THE VARIATION OF LATITUDE.

By S. C. Chandler.

I.

In the determination of the latitude of Cambridge with the Almucantar, about six years and a half ago (*A.N.* 112), it was shown that the observed values, arranged according to nights of observation, exhibited a decided and curious progression throughout the series (see p. 116), the earlier values of C—O being positive, the later ones negative, and the range from November, 1884, to April, 1885, being about four-tenths of a second. There was no known or imaginable instrumental or personal cause for this phenomenon, yet the only alternative seemed to be an inference that the latitude had actually changed. This seemed at the time too bold an inference to place upon record, and I therefore left the results to speak for themselves. The subsequent continuation of the series of observations to the end of June, 1885, gave a negative maximum about May 1, while the discussion of the previous observations from May to November, 1884, gave a positive maximum about Sept. 1, indicating a range of 0″.7 with a half-period of about seven months. In the article above cited I had confined the discussion to stars between —5° and +5° declination, these being most suitable, from their large latitude coefficients. A discussion based on more northerly stars (+5° to +50°), however, independently gave an exactly corresponding variation of latitude both in direction and range. Moreover I had used only observations after 1884 Nov. 8, for reasons which will be understood by reference to *H.C.O. Annals*, XVII, pp. 26-28, 63 and 139-143. It is there shown that the effect of a deviation from verticality of the upright axis carrying the trough, upon that of the float carrying the telescope, is exceedingly small, only one-eightieth part. For instance, if the former were 5″ the latter is but 0″.06. Although there is no record of readings of the level on the upright axis, still as it was carefully adjusted at the beginning, and found to be correct at the end of the period in question, and so remained, without adjustment, throughout the rest of the series to the summer of 1885; and as the correction

is at most so trivial, only a few hundredths of a second of arc, I think we may accept the latitudes deduced before 1884 Nov. 8, with entire confidence. I therefore give the results of the whole series, from stars south of +50°. They may be deduced very simply, for observations on and after 1884 Nov. 8, by the formula — 42° 22′ 18″.13 — $\frac{e-c}{L}$ (see p. 85, l.c.); 42° 22′ 18″.13 being the latitude used in the reductions (p. 91, line 10), *e* being given for each observation in the last column pp. 195-213, the latitude coefficient *L* for each star on pp. 214-222, and *c* on pp. 67-80, or it can be interpolated from the table on p. 85. Before 1884 Nov. 8, the reductions were made with various values of the latitude (see p. 63), but for this investigation the values of *e* may be made entirely homogeneous by using *e* + *Ly*, the values of — *Ly* being taken from the column next to the last, pp. 185-191.

Only four dates were omitted, there being either no polars for instrumental correction, or but one prime-vertical star on one side of the meridian for clock-correction.

The following table gives the values of *Δφ*, (C—O), for each night, with the number of observations and approximate sum of the latitude coefficients, to indicate the relative weights.

Date 1884	Obs.	ΣL	Δφ C—O ″	Date 1885	Obs.	ΣL	Δφ C—O ″
May 29	6	0.8	—0.07	Jan. 2	7	1.6	+0.10
30	10	3.9	+ .26	5	6½	1.4	+ .25
June 1	15	5.0	+ .17	26	7	0.7	— .94
2	9	1.5	+ .11				
4	15	4.9	+ .32	Feb. 7	9	0.6	+ .13
8	7	3.3	+ .22	12	10	0.8	— .43
15	5	1.0	+ .30	23	10	2.2	— .21
17	8	2.0	— .11	25	13	3.1	— .15
July 10	6	0.7	+ .29				
26	6	0.6	+ .16				
30	7	0.8	— .01	Mar. 2	15	3.1	+ .19
				5	9	2.2	+ .27
				6	11	2.8	+ .13
Aug. 1	10	1.2	+ .56	17	9	1.5	+ .03
20	6	0.6	+ .09	21	7	1.3	— .71
23	10	2.6	+ .81				
27	9	1.0	+ .56				
Sep. 20	5	0.5	+ .02	Apr. 1	11	2.1	— .37
26	9	0.8	+ .24	6	11½	4.8	— .36
29	7	0.6	+ .17	9	4	1.0	— .80
Oct. 5	7	0.7	+ .01	10	14	2.1	+ .02
				19	27	6.6	— .18
Nov. 8	11	1.8	+ .16	20	8½	1.9	— .81
9	11	3.9	+ .24				
10	15	4.2	+ .15	May 9	8	6.0	— .54
29	20	2.9	+ .05	10	16	8.2	— .43
				17	12	7.0	— .26
Dec. 3	12	1.9	+ .22	21	9	4.3	— .65
7	6	0.6	+ .40	28	11½	7.6	— .57
8	9	0.8	+ .08				
16	13½	1.6	— .15	June 3	8	3.4	— .02
23	12	1.2	+ .28	22	14	3.6	— .30
29	8½	1.7	+0.09	25	9	2.4	+0.25

Grouping the results according to the horizontal lines in the table, we have:

Date 1884	Obs.	ΣL	C—O ″	Date 1885	Obs.	ΣL	C—O
June 19	94	24.6	+0.19	Jan. 11	20½	3.7	+0.09
Sept. 7	63	11.0	+ .19	Feb. 17	12	6.8	— .19
Nov. 14	60	12.9	+ .20	Mar. 13	54	10.9	+ .01
Dec. 14	61	7.8	+0.12	Apr. 13	79	18.5	— .34
				May 21	56½	33.1	— .48
				June 17	31	9.4	—0.05

A fair curve drawn through these residuals gives:

Minimum latitude 1884 Sept. 1
Maximum " 1885 May 1

thus a half-period of apparently 222 days, with a range of about 0″.7.

To show that the sequence of the values is not accidental, the results are given separately from observations east and west of the meridian, as follows:

Date	West			East		
	Obs.	ΣL	C—O ″	Obs.	ΣL	C—O ″
1884 June 19	38	5.9	+0.03	56	18.7	+0.24
Sept. 7	31	6.6	+ .35	32	4.4	+ .56
Nov. 14	29	8.1	+ .20	31	4.8	+ .19
Dec. 14	32½	5.2	+ .11	28½	2.6	+ .14
1885 Jan. 11	12½	2.9	+ .19	8	0.8	— .28
Feb. 17	21	3.8	— .18	21	3.0	— .20
Mar. 13	33	5.6	— .22	21	5.3	+ .36
Apr. 13	41	9.6	— .30	38	8.9	— .38
May 21	23	12.4	— .62	33½	20.7	— .39
June 17	16	6.9	—0.14	15	2.5	+0.17

Treating the results independently also for groups in declination, —5° to +15°, and +15° to +50°, we get:

Date	South of +15°			North of +15°		
	Obs.	ΣL	C—O ″	Obs.	ΣL	C—O ″
1884 June 19	50	20.5	+0.22	44	4.1	+0.03
Sept. 7	17	7.5	+ .56	46	3.5	+ .31
Nov. 14	35	10.8	+ .19	25	2.1	+ .25
Dec. 14	15	3.8	— .06	46	1.4	+ .30
1885 Jan. 11	6½	2.6	+ .21	14	1.1	— .19
Feb. 17	14	4.7	— .13	28	2.1	— .30
Mar. 13	20	8.1	+ .05	34	2.8	— .02
Apr. 13	32	14.5	— .32	47	4.0	— .37
May 21	34½	31.2	— .47	22	1.9	— .52
June 17	17	8.2	—0.06	14	1.2	—0.03

It thus appears that the apparent change in the latitude of Cambridge is verified by this discussion of more abundant material. The presumption that it is real, on this determination alone, would justify further inquiry.

Curiously enough Dr. KUSTNER, in his determination of the aberration from a series of observations coincident in time

with those of the Almucantar, came upon similar anomalies, and his results, published in 1888, furnish a counterpart to those which I had pointed out in 1885. The verification afforded by the recent parallel determinations at Berlin, Prague, Potsdam and Pulkowa, which show a most surprising and satisfactory accordance, as to the character of the changes in range and periodicity, with the Almucantar results, has led me to make [illegible] investigation of the subject. They seem to establish [illegible] changes, and I will present [illegible]

Cambridge, 1891 *November* 6.

OBSERVATIONS OF WOLF'S PERIODIC COMET.

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 26-INCH EQUATORIAL.

BY PROF. E. FRISBY, U.S.N.

[Communicated by the Superintendent.]

1891 Washington M.T.	*	No. Comp.	☌ — * Δα	☌ — * Δδ	☌'s apparent α	☌'s apparent δ	log pΔ	
d h m s			m s	′ ″	h m s	° ′ ″		
Sept. 24 11 30 10.4	1	24 , 2	+0 1.29	+1 56.9	4 18 9.33	+16 51 43.4	[illegible]	[illegible]
Oct. 3 10 59 0.2	2	15 , 3	−3 29.60	−5 25.1	4 29 35.56	+12 12 4.1	[illegible]	[illegible]

Mean Places for 1891.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	4 18 5.96	+2.08	+16 49 33.1	+13.4	Weiss's Bessel 2 IV, 332
2	4 33 2.86	+2.19	+12 17 16.5	+12.7	½ (Schjellerup + Gran[illegible])

OBSERVATIONS OF COMET *d* 1891 (*BARNARD, SEPT. 27*).

MADE WITH THE 15-INCH EQUATORIAL OF THE HARVARD COLLEGE OBSERVATORY.

BY O. C. WENDELL, ASSISTANT.

[Communicated by Professor EDWARD C. PICKERING, Director.]

1891 Cambridge M.T.	*	No. Comp.	☌ — * Δα	☌ — * Δδ	☌'s apparent α	☌'s apparent δ	log pΔ	
d h m s			m s	′ ″	h m s	° ′ ″		
Oct. 8 9 5 27	1	7	−0 38.49	−2 24.0	20 53 23.18	+0 24 0.4	9.184	0.770
9 8 20 55	1	8	−0 15.87	+9 30.7	20 53 45.49	+0 35 55.1	8.88[illegible]	0.768
21 9 7 7	2	7	−2 26.11	+13 13.3	21 9 21.52	+1 23 54.5	9.372	0.741

Mean Places for 1891.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	20 53 59.38	+1.99	+0 26 13.8	+10.6	W. Bess. XX, [illegible]
2	21 11 15.81	+1.82	+1 10 28.8	+12.4	Lal. 41[illegible]

REDISCOVERY AND OBSERVATIONS OF THE PERIODIC COMET OF SWIFT, 1880 IV (*d 1891*),

BY E. E. BARNARD.

This comet, which was originally discovered by TEMPEL in 1869 (☄ 1869 III), and rediscovered at its return in 1880 (☄ 1880 IV) by SWIFT, has been carefully searched for, with the 12-inch equatorial, during the past three months.

On the night of the 27th, after searching for it, I was sweeping to the southwest of the ephemeris-position, not specially looking for the comet, as I supposed its position would be pretty closely predicted, and ran upon an exceedingly faint nebulosity, closely involving a faint star. The object was so difficult that no observation was obtained, though its place was closely located by the small star, and the time recorded. An examination on Sept. 28 showed that the object was a comet. It was then observed with the micrometer.

On Sept. 29, I carefully observed the point where the comet was seen on the 27th. This could be quite accurately done, and the position so obtained will not be more than 3″ or 4″ in error.

At first there was some doubt of its being the expected comet, but as the four nights' observations give essentially the same correction to the ephemeris, I have assumed it to be that object.

The correction to the ephemeris is very large, the comet being some 14′ west, and 3° 3′ south of the position assigned it by Mr. BOSSERT in the *Bulletin Astronomique*. It is of the $13\frac{3}{4}$ or 14 magnitude.

Mt. Hamilton, 1891 *Sept.* 30.

FILAR-MICROMETER OBSERVATIONS OF THE TEMPEL-SWIFT PERIODIC COMET,

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY, BY E. E. BARNARD.

Mt. Hamilton M.T. 1891	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
d h m s			m s	′ ″	h m s	° ′ ″		
Sept. 27 8 36 31	1	6 , 1	+3 11.05	−3 40.0	20 54 9.98	−1 32 22.9	8.301	0.757
28 8 38 2	2	6 , 1	−3 39.21	−1 30.6	20 53 45.43	−1 22 36.2	8.491	0.717
29 9 5 20	3	10 , 4	−2 7.07	−1 22.2	20 53 23.71	−1 12 59.8	8.982	0.713
30 8 5 16	4	10 , 4	+1 18.44	+5 2.9	20 53 6.0	−1 2.9	*n*8.301	0.737

Mean Places for 1891.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	20 50 56.75	+2.18	−1 28 53.1	+10.2	W.B. XX, 1254
2	20 57 22.17	+2.17	−1 21 15.8	+10.2	Gould 28858
3	20 55 28.62	+2.16	−1 11 17.8	+10.2	W.B. XX, 1352
4	20 51 45.4	+2.15	−1 8.1	+10.3	DM. −1°4083

OBSERVATIONS OF SATELLITES OF *SATURN* AT PRINCETON, N.J., IN 1891,

COMMUNICATED BY PROF. C. A. YOUNG.

[All times are "Eastern Standard," five hours slow of Greenwich Mean Time.]

1. Reappearance of satellites from eclipse.

(1.) April 8. *Rhea.* Halsted Obs'y. C.A.Y. Obs.

Satellite reappeared at $8^{h}\,56^{m}.0 \pm 30^{s}$. The phenomenon had not been looked for, but was observed unexpectedly, and the time is a little uncertain.

(2.) April 17. *Rhea.* Halsted Obs'y. C.A.Y. Obs.

	h m s
Satellite first glimpsed at	9 53 45
Bright as *Enceladus*,	9 54 50 $\pm 5^{s}$
Bright as *Tethys*,	9 56 20 $\pm 10^{s}$
Full brightness before,	9 57 30

(3.) April 26. *Rhea.* Halsted Obs'y. TAYLOR REED Obs.

	h m s
First seen,	10 52 4
Bright as *Enceladus*,	10 53 24 $\pm 5^{s}$
Bright as *Dione*,	10 54 19 $\pm 15^{s}$
Bright as *Tethys*,	10 54 34 $\pm 15^{s}$
Full brightness,	10 57 0 $\pm 1^{m}$

Same phenomenon observed at the School of Science Observatory, by C.A.Y., with $9\frac{1}{2}$-inch telescope.

	h m s
First seen,	10 53 2
Bright as *Tethys*,	10 54 37 $\pm 5^{s}$

(4.) April 27. *Dione.* Halsted Obs'y. C.A.Y. Obs.

Satellite first seen 8ʰ 58ᵐ 30ˢ; full light regained in about 1ᵐ. Same observed at School of Science Observatory by T. REED. Satellite first seen 8ʰ 58ᵐ 30ˢ (exactly the same as observed by C.A.Y. with the 23-inch; probaby Y.'s observation was late.)

II. Configurations of satellites. (All the observations were made with the 23-inch equatorial.)

(1.) April 13. *Mimas.* Halsted Obs'y. C.A.Y. Obs.

Superior conjunction with western extremity of the ring at 11ʰ 10ᵐ 15ˢ ±30ˢ. Power 360. Seeing 7 (on scale of 10). Observations satisfactory.

(2.) April 15. *Mimas.* Halsted Obs'y. C.A.Y. Obs.

Superior conjunction with western end of the ring at 8ʰ 16ᵐ.5 ±2ᵐ. Power 360. Observation difficult from unsteadiness of the seeing. Satellite not seen after 8ʰ 23ᵐ.

(3.) April 27. *Dione.* Halsted Obs'y. C.A.Y. Obs.

Superior conjunction with eastern end of [illegible] 26ᵐ 30ˢ ±30ˢ. Power 360. Observation satisfactory.

(4.) April 29. *[illegible]* Halsted Obs'y. C.A.Y. Obs.

Inferior conjunction with eastern end of ring [illegible] 22ᵐ ±1ᵐ. Power 360.

(5.) May 7. *Tethys.* Halsted Obs'y. C.A.Y. Obs.

Superior conjunction with western end of ring [illegible] 11ᵐ ±0ᵐ.5. Power 480. *Tethys* after w[illegible] limb of the planet, the last contact [illegible] at 11ʰ 15ᵐ 50ˢ ±15ˢ. The satellite hung on the [illegible] planet for about 30ˢ. The observation was [illegible] difficult but on the whole satisfactory.

The same evening the eastern elongation of *Mimas* was watched from 9ʰ 25ᵐ to 10ʰ 0ᵐ. The elongation was judged to have occurred at 9ʰ 15ᵐ ±5ᵐ.

DISCOVERY AND OBSERVATIONS OF A COMET (1891).

BY E. E. BARNARD.

On the morning of October 3, while sweeping for comets with the 4-inch broken-tube comet seeker, I found a nebulous object in the field with a 4ᴹ star. Upon examining this with the 12-inch it was found to be a new comet. As daylight was already on hand, there was scarcely time to secure a position, but fortunately, from the proximity of the comparison-star, a few minutes sufficed to fix its place accurately. Even in the very brief interval during which it was seen, motion was detected.

The comet was about 12ᴹ, and 1′ in diameter. [illegible] with no nucleus or tail.

Following are the observations so far secured of it. From these three positions Mr. CAMPBELL computed his orbit for the comet, on the morning of Oct. 5.

Mt. Hamilton, 1891 *October* 22.

FILAR-MICROMETER OBSERVATIONS OF COMET *e* 1891 (*BARNARD Oct. 2*).

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY, BY E. E. BARNARD.

Mt. Hamilton M.T. 1891		*	No. Comp.	☉' — * Δα	☉' — * Δδ	☉'s apparent α	☉'s apparent δ	log. p Δ for α	log. p Δ for δ
d	h m s			m s	′ ″	h m s	° ′ ″		
Oct. 2	16 51 36	1	10 , 3	+0 28.86	— 0 6.3	7 31 25.25	—27 52 18.6	[illegible]	0.88[illegible]
3	16 7 50	2	12 , 4	+0 23.17	+ 0 23.2	7 37 0.86	—29 17 3.5	[illegible]	0.8[illegible]
4	16 1 35	3	4 , 3	—1 25.32	—15 4.7	7 42 54.06	—30 43 52.6	[illegible]	0.860
5	15 55 14	4	12 , 4	—1 16.94	— 3 29.4	7 48 58.79	—32 15 32.6	9.784	0.859
6	16 15 19	5	14 , 4	+0 21.55	— 0 6.3	7 55 19.67	—33 36 47.8	9.599	0.872
7	16 23 38	6	2	. . . . . .	+ 6 39.7	. . . . . .	—35 1 12.5	. . .	0.88[illegible]
	16 49 27	6	12	—3 5.89	. . . . .	8 1 57.65	. . . . . .	9.702	. . . .
8	16 11 18	7	12 , 4	—0 5.31	— 3 26.4	8 8 26.27	—36 23 34.6	9.576	0.874
9	16 16 5	8	*4 , 3	+0 7.71	+ 5 9.9	8 15 15.58	—37 11 39.0	9.587	0.873

* Difference of right-ascension measured direct with micrometer

Mean Places for 1891.0 of Comparison-Stars.

⁎	α	Red. to app. place	δ	Red. to app. place	Authority
		s	° ′ ″	″	
1	7 30 55.66	+0.73	—27 52 29.5	+17.2	Washington
2	7 36 37.01	+0.68	—29 17 13.9	+17.2	Gould 9952
3	7 44 18.72	+0.66	—30 29 5.1	+17.2	Gould 10210
4	7 50 15.12	+0.61	—32 12 20.3	+17.1	Wash. Mer. Tr. Zone 217, No. 64
5	7 54 54.55	+0.57	—33 36 58.3	+16.8	Wash. Mer. C. Zone 166, No. 11
6	8 5 3.02	+0.52	—35 8 8.8	+16.6	Gould 10820
7	8 8 31.08	+0.50	—36 20 21.5	+16.3	Wash. Mer. C. Zone 171, No. 26.
8	8 15 7.38	+0.46	—37 50 1.9	+16.0	Wash. Mur. Zone 234, No. 26.

October 4. In the right-ascension observations the comet and star were in the extreme edge of the field, and the right-ascension therefore is not so reliable as it might be.

The rapid southeast motion of the comet soon carried it below our horizon, and consequently but few observations were obtained of it. It could have been followed a few days longer, but a thick southeastern sky prevented it being seen after the 9th.

Some of the comparison-stars were difficult of identification. Star 4 may be wrongly identified.

NEW ASTEROIDS.

An asteroid of the thirteenth magnitude was discovered by CHARLOIS, at Nice, October 8, in the position,

Oct. 8.5915 Gr. M.T. $\alpha = 0^h\ 12^m\ 27^s.7$, $\delta = +3^\circ\ 21'\ 54''$. Daily motion, —36ˢ in right-ascension, and 8′ southward.

An asteroid of the thirteenth magnitude was discovered by PALISA, at Vienna, Oct. 11, in the position,

Oct. 11.4056 Gr. M.T. $\alpha = 1^h\ 19^m\ 40^s.4$, $\delta = +13^\circ\ 41'\ 56''$. Daily motion, —44ˢ in right-ascension, and 8′ southward.

An asteroid of the twelfth magnitude was discovered by PALISA, at Vienna, Oct. 15, in the position,

Oct. 15.1177 Gr. M.T. $\alpha = 2^h\ 18^m\ 18^s.0$, $\delta = +13^\circ\ 12'\ 34''$. Daily motion, —18ˢ in right-ascension, and 3′ southward.

The small planet discovered by PALISA August 14 (*A.J.* XI 34) proves to have been no. 149, *Medusa*, and the identity of the second of Sept. 1 with no. 291, *Alice*, has been confirmed. The notation thus becomes

311	CHARLOIS,	June 11	314	CHARLOIS,	Sept. 1	317	CHARLOIS,	Sept. 9
312	CHARLOIS,	Aug. 28	315	PALISA,	Sept. 4	318	CHARLOIS,	Sept. 24
313	PALISA,	Aug. 30	316	CHARLOIS,	Sept. 8			

The three, now announced, will therefore bear the numbers 319 to 321, on the assumption that they have not been previously seen.

Names have been assigned as follows:

299	*Thora*,	304	*Olga*,	309	*Fraternitas*,
301	*Bavaria*,	306	*Unitas*,	313	*Chaldea*.

The name for no. 313 was assigned by Miss CATHERINE W. BRUCE, of New York, at the invitation of Dr. PALISA, in token of the gratitude of astronomers.

CONTENTS.

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ON THE VARIATION OF LATITUDE,

BY S. C. CHANDLER.

II.

Before entering upon the details of the investigations spoken of in the preceding number, it is convenient to say that the general result of a preliminary discussion is to show a revolution of the earth's pole in a period of 427 days, from west to east, with a radius of thirty feet, measured at the earth's surface. Assuming provisionally, for the purpose of statement, that this is a motion of the north pole of the principal axis of inertia about that of the axis of rotation, the direction of the former from the latter lay towards the Greenwich meridian about the beginning of the year 1890. This, with the period of 427 days, will serve to fix approximately the relative positions of these axes at any other time, for any given meridian. It is not possible at this stage of the investigation to be more precise, as there are facts which appear to show that the rotation is not a perfectly uniform one, but is subject to secular change, and perhaps irregularities within brief spaces of time.

The evidence upon the several points covered in the above statement will appear in course of the presentation of the various discussions, which I will now proceed to take up in a convenient order.

First, it is instructive to compare the results which may be deduced from Dr. KÜSTNER's memoir on the aberration-constant, determined with a universal transit-instrument, at Berlin, in 1884–85, with the contemporaneous almucantar observations. I have computed the following table from the data on pp. 38–41, 57, of that memoir. The first column indicates the grouping of the observations; the second to the eighth columns give, for each pair of stars, the observed value of the latitude (above 52° 30′ 16″.00), with the number of observations. The last two columns give the mean value for each group and the deviation (C—O) from an assumed value, 52° 30′ 16″.70. The mean value of the latitude actually given by the whole series is 16″.82, but it is evident that if the hypothesis of a 427-day period is correct, the true mean value could only be found from a series covering an interval of fourteen months.

	I	II	III	IV	V	VI	VII	Mean	C—O
1884	″	″	″	″	″	″	″	″	″
Apr. 2 – Apr. 26	0.75 10	0.67 4	0.36 5	0.86 10	1.00 6	0.82 3	. . .	16.765 38	—0.065
28 – May 24	. . . .	0.67 1	0.42 1	0.72 1	1.02 9	0.87 7	0.85 5	.890 24	— .190
May 22 – July 30	0.79 3	. . .	. . .	. . . .	1.16 3	1.02 3	0.90 7	.952 16	— .252
Aug. 1 – Aug. 14	0.90 10	1.07 6	0.62 5	1.08 1	. . . .	. . . .	. . .	.890 22	— .190
16 – 28	0.89 11	1.02 5	0.51 6	1.12 11	. . . .	. . . .	. . .	.959 33	— .259
Sept. 21 – Oct. 18	1.07 7	1.03 6	0.92 9	. . . .	. . . .	. . . .	. . .	.996 22	— .296
Oct. 20 – Nov. 30	. . . .	. . .	. . .	. . . .	1.06 10	0.90 10	0.85 9	.940 29	— .240
1885									
Mar. 12 – Mar. 31	0.51 6	0.40 3	0.31 4	0.59 3	. . . .	. . . .	. . .	.455 16	+ .245
Apr. 13 – Apr. 30	0.70 6	0.58 3	0.12 4	0.66 7	0.64 5	1.07 2	. .	.611 27	+ .089
May 7 – May 28	. . . .	. . .	. . .	. . . .	0.82 5	0.70 7	0.57 5	16.698 17	+ 0.002

The various pairs of stars are in good harmony as to the nature of the latitude-change, which is clearly interpreted from the mean values and residuals in the last columns. For convenient comparison with the simultaneous variations going on at Cambridge, the following parallel statement will be serviceable.

		Almucantar	Küstner
		"	"
1884	Apr. 11	. . .	—0.06
	May 10	. . .	— .19
	June 14	. . .	— .25
	19	+0.19	. . .
	Aug. 7	. . .	— .19
	Aug. 21	. . .	— .24
	Sept. 7	+ .19	. . .
	Oct. 8	. . .	— .30
	Nov. 1	. . .	— .24
	14	+ .20	. . .
	Dec. 14	+ .12	. . .
1885	Jan. 11	+ .09	. . .
	Feb. 17	— .19	. . .
	Mar. 13	+ .04	. . .
	23	. . .	+ .24
	Apr. 13	— .34	. . .
	21	. . .	+ .09
	May 11	. . .	0.00
	21	— .48	. . .
	June 17	—0.05	. . .

Thus, in the autumn of 1884, when the Cambridge latitudes were the smallest, those of Berlin were the largest; while in the spring of 1885 this condition was reversed. The break of four months in the Berlin series unfortunately prevents our fixing the epoch of minimum with certainty, but it probably occurred in January or February of 1885; while at Cambridge this phase was in September or October of 1884. If the values in the table be charted and curves drawn, it will be evident on trial that they can be made to correspond satisfactorily by assuming that the occurrence of any given phase at Cambridge preceded that at Berlin by about one-quarter of the period of 427 days, but not at all by assuming that it followed by that amount. This would apparently indicate that the polar motion is from west to east, or in the direction of increasing right-ascension. It will be seen later that this hypothesis conforms with the other evidence bearing on this point.

I now take up the observations with the Pulkowa vertical circle, which have been provocative of so much inquiry, so far without any solution of the anomalies which they show, in regard to this question of latitude-variation. The results for each of the observers will be treated separately, to eliminate the possible effect of personal equation. In order to show convincingly the existence of the 427-day period, as well as to illustrate the method pursued in discussing all the series hereafter to be presented, I will give in detail the process as applied to Gyldén's observations of *Polaris*, in order to afford means for searching criticism as to the allowability of the method. In view of the importance of the subject, there seems to be no reason to apologize for this circumstantiality in the case of one series. In presenting the results similarly deduced from the other series, it will suffice to give only such data as will enable any one to verify them easily.

Gyldén's observations, as employed by Nyrén to deduce the latitude of Pulkowa, are given on pp. 23–27 of his memoir. The last column, *n'*, of that table gives the deviations (O—C) of the observed values of the latitude, after reducing to the latitude 59° 46′ 18″.654, and the correction to the declination —0″.03, found from Gyldén's observations alone, and to the aberration-constant 20″.495, and parallax 0.036, resulting from the combination of **Peters's**, Gyldén's and Nyrén's observations. In the following table, columns 1 and 2 give the mean dates and values of *n'*, following Küstner's classification in groups of 10 observations in general, varied where gaps in the dates require another separation. Column 4 gives the corresponding Julian day. Now it is plain that, if the 427-day period subsists, we ought to find, by adding or subtracting multiples of 427 days, to bring the dates into one period, and by arranging these new dates in numerical order, that the corresponding values of *n'* will fall into an algebraical sequence, within the limits of the accidental errors. Column 5 accordingly gives the dates so modified as to bring them within the limits 2402400–2402800, column 6 indicates the order in this new arrangement, and columns 7 to 10 the data in this new order.

1	2	3	4	5	6	7	8	9	10	11	12
	"										"
1863 Dec. 3	+0.01	10	1843	2697	18	1	2419	—0.28	10		
1864 Feb. 14	— .10	10	1916	2770	23	2	2426	— .17	10	2402427	—0.17
Apr. 2	— .13	10	1964	2818	26	3	2435	— .05	10		
May 7	— .17	10	1999	2426	2	4	2443	— .21	6		
June 20	+ .04	10	2043	2470	6	5	2468	— .31	10	2463	— .15
July 9	+ .01	7	2062	2489	7	6	2470	+ .04	10		
Sept. 17	+ .26	11	2132	2559	11	7	2489	+ .01	7		
Oct. 8	+ .28	10	2153	2580	13	8	2507	— .04	10	2513	— .03
Nov. 7	+ .26	10	2183	2610	15	9	2537	— .06	9		
1865 Mar. 19	— .08	12	2315	2742	20	10	2551	+ .19	3		
Apr. 7	— .16	10	2334	2761	22	11	2559	+ .26	11	2402562	+0.01
Apr. 23	—0.17	10	2360	2787	24	12	2567	—0.19	12		

1	2	3	4	5	6	7	8	9	10	11	12
	″							″			
1865 May 9	−0.21	6	2366	2793	25	13	2580	+0.28	10		
Sept. 27	− .04	10	2507	2507	8	14	2607	+ .02	3	2402597	+0.24
Nov. 10	+ .19	3	2551	2551	10	15	2610	+ .26	10		
1866 Sept. 17	− .05	10	2862	2435	3	16	2617	+ .38	12		
Oct. 20	− .31	10	2895	2468	5	17	2661	+ .39	1	2669	+ .21
1867 May 4	+ .39	1	3091	2664	17	18	2697	+ .01	10		
Oct. 10	− .22	10	3250	2823	27	19	2714	+ .02	3		
Nov. 2	− .28	10	3273	2419	1	20	2742	− .08	12	2732	− .12
1868 Mar. 29	− .19	12	3124	2567	12	21	2760	− .24	8		
June 17	+ .38	12	3501	2617	16	22	2761	− .16	10		
Oct. 8	− .24	8	3614	2760	21	23	2770	− .10	10	2753	− .14
1869 Apr. 30	− .06	9	3818	2537	9	24	2787	− .17	10		
July 9	+ .02	3	3888	2607	11	25	2793	− .21	6		
Oct. 21	+ .02	3	3995	2714	19	26	2818	− .13	10	2402814	−0.18
1870 Mar. 29	−0.21	6	4151	2413	4	27	2823	−0.22	10		

The progression of the values of *u′* in column 9 leaves nothing to be desired, and is still more striking in the means, columns 11 and 12, taken in groups of three, by weights.

It seems to me, then, that this series attests in the most satisfactory manner the reality of the 427-day period. The results given will hereafter enable us to assign normal epochs for the maximum and minimum latitudes according to this series, when we come to combine it with others to ascertain the most probable value of the period, and the nature of its variations from uniformity.

The evidence of this 427-day period ought to appear in a similar way from stars south of the zenith, and to test whether it does so I have selected from volume XIV of the *Pulkowa Observations* the following fifteen stars culminating within 50° of the zenith, south, and which were observed by Gyldén between 1863 and 1867 at least ten times each:

α Andromedae,
γ Pegasi,
α Arietis,
α Persei,
α Tauri,
α Aurigae,
β Tauri,
β Geminorum,
α Leonis,
α Bootis,
α Coronae,
α Lyrae,
γ Aquilae,
α Cygni,
α Pegasi.

After deducting each observed declination from the mean of all, for each star, the residuals were arranged according to the month of observation, and the means taken. Treating the results exactly as we have done those of *Polaris*, by applying multiples of 127 days to the dates, to refer all to the period between 2402400–2402800, Julian dates, we get as follows:

	″
2402421	+0.03
2451	+ .03
2506	+ .11
2560	+ .19
2598	+ .24
2665	+ .03
2729	− .22
2787	−0.25

Comparing this with the last two columns of the table for *Polaris*, above given, we see the same phenomenon exhibited; if in a less striking degree, it must be remembered that the means of the observed declinations, with which the residuals for each star are formed, are only partially freed from the effect of the latitude-variation, the observations being neither sufficiently numerous nor well distributed to eliminate it, except imperfectly. This subject deserves a more complete discussion than I have here given it.

I now present, in the table below, Nyrén's observations of the latitude of Pulkowa, treated exactly in the same way as Gyldén's. In the memoir above quoted Nyrén has employed his own observations to 1873 May 1. In volume XIV of the *Pulkowa Observations*, however, there are 82 more observations of *Polaris*, bringing the series down to 1875 July 9. I have reduced these in a precisely similar way, forming values of *u′* which are homogeneous with, and may be regarded as a continuation of, the last column of page 29 of the memoir in question.

1	2	3	4	5	6	7	8	9	10	11	12
	″										″
1871 July 10	−0.01	13	4619	5046	2	1	5033	−0.04	10		
Nov. 28	+ .15	13	4760	5187	8	2	5046	− .01	13	2405040	0.01
1872 Mar. 20	− .05	14	4873	5300	17	3	5070	− .02	10		
Apr. 27	− .16	10	4911	5338	20	4	5090	− .02	10	2405101	0.00
May 15	−0.18	10	4929	5356	21	5	5151	+0.04	10		

1	2	3	4	5	6	7	8	9	10	11	12
	″							″			″
1872 June 11	—0.10	10	4956	5383	22	6	5158	+0.20	11		
Aug. 27	— .01	10	5033	5033	1	7	5178	+ .28	5	2405171	+0.19
Oct. 3	— .02	10	5070	5070	3	8	5187	+ .15	13		
Oct. 23	— .02	10	5090	5090	4	9	5199	+ .10	10		
Dec. 23	+ .01	10	5151	5151	5	10	5207	+ .08	10	5206	+ .14
1873 Feb. 17	+ .08	10	5207	5207	10	11	5215	+ .27	7		
Mar. 18	+ .10	10	5236	5236	12	12	5236	+ .10	10		
Apr. 1	+ .01	13	5250	5250	14	13	5239	+ .19	10	5242	+ .09
Apr. 23	— .02	12	5272	5272	16	14	5250	+ .01	13		
May 30	— .02	10	5309	5309	18	15	5268	+ .08	12		
June 25	— .09	9	5335	5335	19	16	5272	— .02	12	5281	.00
1874 Apr. 12	+ .10	10	5626	5199	9	17	5300	— .05	14		
May 22	+ .19	10	5666	5239	13	18	5309	— .02	10		
June 20	+ .08	12	5695	5268	15	19	5335	— .09	9	5327	— .09
Oct. 19	— .06	7	5816	5389	23	20	5338	— .16	10		
1875 May 3	+ .20	11	6012	5158	6	21	5356	— .18	10		
May 23	+ .28	5	6032	5178	7	22	5383	— .10	10	2405375	—0.12
June 29	+0.27	7	6069	5215	11	23	5389	—0.06	7		

Grouping these values, which represent the excess of the observed latitudes over 59° 46′ 18″.50, we have, in columns 1, 2 and 3, the mean date, mean value of n', and the number of observations, respectively. The formation of the other columns is the same as in the table of Gyldén's observations, already fully explained.

The observed values of the latitude-deviations, in column 9, fall into place in the progression even more satisfactorily, if possible, than in Gyldén's series. It will be noted, too, that the interval between the normal epochs of maximum latitude, as indicated by the two series, is almost exactly a multiple of 427 days (*i. e.*, approximately, 2405180–2402620 = 2560 = 6 × 426.7). Taking all these facts in connection, there seems to be little room for doubt that this 427-day period furnishes the true key to the troublesome discordances in the Pulkowa latitudes. I now proceed to show that it unlocks as readily the mystery attaching to another series of observations, — one which it has heretofore been attempted to reconcile with Euler's well known theoretical ten-month period, with the same negative result as in the case of the Pulkowa latitudes.

In 1862 Prof. Hubbard began a series of observations of *α Lyrae* at the Washington Observatory with the prime vertical transit-instrument, for the purpose of determining the constants of aberration and nutation and the parallax of the star. The methods of observation and reduction were conformed to those used with such success by W. Struve. After Hubbard's death the series was continued by Professors Newcomb, Hall and Harkness, until the beginning of 1867. Prof. Hall describes these observations as the most accurate determinations of declination ever made at the Naval Observatory. The probable error of a declination from a single transit was ±0″.111, and, judging from the accidental errors, the series ought to give trustworthy results. Upon reducing them, however, it was found that some abnormal source of error existed, which resulted in anomalous values of the aberration-constant in the different years, and a negative parallax in all. A careful verification of the processes of reduction failed to discover the cause of the trouble, and Prof. Hall says that the results must stand as printed, and that probably some annual disturbance in the observations or the instrument occurred, which will never be explained, and which renders all deductions from them uncertain. The trouble could not be connected with personal equation, the anomalies remaining when the observations of the four observers who took part were separately treated. Nor, as Prof. Hall points out, will the theoretical ten-month period in the latitude furnish the explanation.

It is manifest, however, that if the 427-day period exists, its effect ought to appear distinctly in declination-measurements of such high degree of excellence as these presumably were, and, as I hope satisfactorily to show, actually are. When this variation is taken into account, the observations will unquestionably vindicate the high expectations entertained with regard to them by the accomplished and skilful astronomers who designed and carried them out.

The method of treating these observations in the present discussion is as follows. Grouping the individual measurements as given by Prof. Hall (*Astronomical Journal*, VIII, pp. 1–5, 9–13), we have the mean date, the number of observations, and the mean value of n, in the first three columns below. The quantity n is the value of $\Delta\delta$ (C—O) reckoned with an assumed declination, and referred to Struve's constant of aberration. From the various determinations of the parallax of the star deserving of confidence, (Hall, 0″.134; Brünnow, 0″.188 and 0″.214; Johnson, 0″.154; Struve, 0″.147;

W. STRUVE, 0″.262; PETERS, 0″.103), we may safely assume the value 0″.15, and with this the corrections in column 4 are computed. Column 5 gives the reduction to NYRÉN's aberration-constant. Column 6 then represents the value of $\Delta\delta$ (C—O), or $\Delta\varphi$ (O—C), freed from parallax and aberration, and subject to the error of the assumed declination, and to the effect of the 427-day period of variation in the latitude. The last column gives the Julian date.

Date	Obs	n	Parall.	Aberr.	$\Delta\varphi$	2 400 000
1862		″	″	″	″	+
Apr. 10	10	−0.073	+0.037	−0.042	−0.078	1241
May 13	10	− .005	+ .100	− .029	+ .066	1274
June 9	10	+ .003	+ .129	− .012	+ .120	1301
June 29	10	− .053	+ .135	.000	+ .082	1321
July 28	10	− .096	+ .116	+ .022	+ .042	1350
Aug. 24	10	− .077	+ .073	+ .036	+ .032	1377
Oct. 6	11	+ .266	− .017	+ .043	+ .292	1420
Oct. 30	11	+ .071	− .069	+ .037	+ .042	1444
Dec. 10	11	+ .007	− .123	+ .013	− .103	1485
1863						
Jan. 26	10	− .102	− .109	− .011	− .222	1532
Mar. 19	10	+ .214	− .014	− .023	+ .177	1584
Apr. 27	9	+ .384	+ .063	− .038	+ .409	1623
June 1	9	+ .008	+ .121	− .018	+ .111	1658
Sept. 17	11	− .148	+ .026	+ .043	− .079	1766
Nov. 6	11	− .064	− .070	+ .035	− .099	1816
Dec. 12	11	− .061	− .125	+ .009	− .177	1852
1864						
Jan. 23	10	− .019	− .114	− .021	− .154	1894
Mar. 8	10	+ .246	− .037	− .042	+ .167	1939
June 5	10	− .061	+ .126	− .015	+ .050	2028
June 28	10	+ .113	+ .134	+ .001	+ .248	2051
July 21	10	+ .074	+ .123	+ .017	+ .214	2074
Aug. 14	10	+ .022	+ .091	+ .032	+ .145	2098
Sept. 25	10	− .020	+ .008	+ .044	+ .032	2140
Oct. 25	10	− .094	− .060	+ .039	− .115	2170
Dec. 1	10	− .220	− .118	+ .018	− .320	2207
1865						
Jan. 19	10	− .165	− .118	− .018	− .301	2256
Mar. 7	10	+ .062	− .012	− .021	+ .001	2303
May 21	10	+ .012	+ .109	− .012	+ .109	2378
June 29	10	− .011	+ .131	+ .002	+ .122	2417
July 31	9	+ .262	+ .112	+ .024	+ .398	2449
Sept. 21	9	+ .270	+ .018	+ .043	+ .331	2501
Nov. 9	9	− .109	− .088	+ .033	− .164	2551
Dec. 7	9	− .297	− .122	+ .015	− .404	2578
1866						
Jan. 26	10	− .453	− .110	− .023	− .586	2628
Feb. 28	10	− .056	− .055	− .040	− .151	2661
Apr. 7	10	− .053	+ .029	− .043	− .067	2699
June 1	10	+ .116	+ .121	− .018	+ .219	2754
July 3	8	− .009	+ .133	+ .004	+ .128	2786
July 23	8	− .033	+ .121	+ .019	+ .107	2806
Aug. 19	8	+ .164	+ .084	+ .034	+ .282	2833
Oct. 1	8	+ .298	− .006	+ .014	+ .306	2876
Oct. 28	9	+ .119	− .063	+ .028	+ .094	2903
Dec. 10	9	+ .123	− .122	+ .013	+ .014	2946
1867						
Jan. 17	8	− .277	− .121	− .016	− .414	2984
Feb. 27	8	+0.097	−0.059	−0.039	−0.001	3025

Referring all the values of $\Delta\varphi$ to a single period, as in the previous discussions, and taking means of three, we find the values in column A below.

Date	A	B	C	Obs
	″			
2 402 201	−0.288	−0.277	−0.256	30
2 236	− .060	− .062	− .066	31
2 268	− .015	− .002	+ .021	31
2 293	+ .007	+ .013	+ .024	32
2 329	− .016	+ .001	+ .034	31
2 368	+ .135	+ .120	+ .090	28
2 390	+ .034	+ .022	+ .001	26
2 433	+ .116	+ .093	+ .046	30
2 458	+ .271	+ .255	+ .224	26
2 485	+ .326	+ .301	+ .251	28
2 510	+ .113	+ .097	+ .066	29
2 532	− .027	− .035	− .051	29
2 563	− .233	− .216	− .183	27
2 589	+ .012	− .005	− .038	30
2 402 608	−0.002	−0.017	−0.017	29

The regular course of the residuals is here indicated in the clearest possible manner, and their periodic character will be still more strikingly apparent in a chart formed from them. To show that this result has in no way been brought about by the particular values attributed to the parallax and the aberration, column *B* is given, computed from $\pi = 0''.10$, and $a = 20''.478$; and *C*, from $\pi = 0.00$, and $a = 20''.445$. In *B* and *C* there is not a single break in the arrangement, each by themselves, of the positive and negative signs, even to the insignificant extent to which it occurs in *A*.

In this connection I desire to state my strong impression that, although the tendency at present among astronomers is to supplant STRUVE's constant of aberration by NYRÉN's, the lower value will very likely prove to be nearer the true one — and, indeed, will be near the resultant value deduced from the very material which NYRÉN employed, when this latitude-variation of 427 days' cycle is eliminated. If we compare the values obtained from the three series,

PETERS's observations,	20.507
GYLDÉN's "	20.469
NYRÉN's "	20.498

remembering that the first and last were deduced from only two years' observations, each, while the middle one covered nearly seven years, it seems probable that the effects of this latitude variation would be much better eliminated from GYLDÉN's series than from the others. In fact, from the nature of the residuals which I have found from NYRÉN's observations of Polaris from 1873 May to 1875 June, I feel as confident as one can be without actual calculation, that if they had been included in his equations of condition, the solution would have given a smaller aberration-constant.

To revert, it seems to me that from what has been shown we can feel assured that the anomalies in the Washington prime-vertical observations have here been traced to their true origin. It remains to make a comparison with the Pulkowa results for the purpose of throwing additional light upon the direction of the polar motion.

The Washington and Pulkowa observations have the interval from 1863 November to 1867 April, in common. From the data at both places during this period, already given, we get in the same way as before, the following values of $\Delta\varphi$.

	Date	Obs.	O	C
			″	″
Washington	2402231	50	−0.28	−0.23
	2315	49	− .01	− .12
	2389	46	+ .15	+ .12
	2460	46	+ .22	+ .23
	2519	47	+ .11	+ .15
	2584	45	− .17	− .06
Pulkowa	2443	30	− .18	− .12
	2489	27	+ .03	+ .03
	2561	21	+ .26	+ .22
	2655	24	+ .18	+ .13
	2757	32	− .11	− .18
	2402800	26	−0.16	−0.23

Now let T be the time when the direction of the north pole of the principal axis from that of the rotation-axis is in the Greenwich meridian, θ the daily angular motion, and r its radius expressed in arc. Then, if φ_0 be the mean latitude of a place whose longitude from Greenwich is λ, the observed latitude at any other time, t, will be

$$\varphi = \varphi_0 - r\cos[\lambda \pm (t-T)\,\theta],$$

the upper sign obtaining if the motion is from west to east, the lower if from east to west, and $t-T$ being expressed in days. On the first hypothesis we find, from a least-square solution of the twelve equations furnished by the above twelve values of $\Delta\varphi$, giving equal weights, and introducing the values of λ, −30° for Pulkowa and +77° for Washington,

$$r = 0.230, \qquad T = 2402338$$

which, substituted in the above equation, give the column C in the table. If, on the contrary, we attempt to make the solution with the lower sign, we cannot satisfy the observations at all, the residual errors being fully as great as the original values of $\Delta\varphi$. Indeed, without resort to any refinement of computation, if we merely chart the observed quantities at Pulkowa and Washington, draw fair curves, and compare the intervals between the two curves at the principal points, we find that the times at Washington precede those at Pulkowa by

192 days for the minimum,
162 days for the zero point, increasing,
155 days for the maximum,
175 days for the zero point, decreasing,

the mean being 171 days. Now, if the motion is from east to west, any given phase at Washington should follow that at Pulkowa by 128 days, but for a west to east motion it should precede by the same amount.

We thus find that the comparison of the simultaneous series at Pulkowa and Washington, 1863–1867, leads to the same conclusion as that already drawn from the simultaneous series at Berlin and Cambridge, 1884–1885. The direction of the polar motion may therefore be looked upon as established with a large degree of probability.

In the next paper, I will present the results derived from PETERS, STRUVE, BRADLEY, and various other series of observations, after which the results of all will be brought to bear upon the determination of the best numerical values of the constants involved.

ON THE VARIABLE *U CASSIOPEAE* (CH. 243).

BY S. D. TOWNLEY.

[Communicated by Prof. GEORGE C. COMSTOCK, Director of the Washburn Observatory.]

In the *Companion to The Observatory*, for 1891, predicted maxima for this star are 1891 March 7 and 1891 November 22, giving a period of 260 days. I have observed this star with the 15½-inch equatorial of the Washburn Observatory, and find results quite different from those given above. My first series of observations, 13 in number, extends from 1889 December 6, to 1890 April 8, and gives a maximum of $8^{\mathrm{M}}.8$ on 1889 December 21. On 1890 March 31 and April 8, the variable was invisible, but could not be followed on its return to visibility on account of proximity to the sun. The second series, of 30 observations, extends from 1890 July 15 to 1891 April 4. These give a maximum of $8^{\mathrm{M}}.0$ 1890 September 27 and a minimum of something less than 15^{M} for 1891 February 21. On 1891 March 7, the predicted time of maximum according to *The Observatory* the star was invisible with this telescope. The star was 80 days below the 14 magnitude. The third series, 12 observations, extends from 1891 September 12 to the present time, but during this period the star has passed through neither a maximum nor a minimum. The last time observed, November 8, the variable was invisible. On November 5, with good seeing, I could get glimpses of the variable as the merest speck of light, so that it could not have been brighter than $14^{\mathrm{M}}.5$, and was probably about 15^{M}.

The star will return to visibility in this telescope about 1892 January 10, and with observations for two months after that, a fairly well determined minimum ought to be obtained. Instead of being at a maximum on 1891 November 22, the star will be at about a minimum. The light-curve from these observations gives a period of 286 days, which is longer by 26 days than that given by *The Observatory*. CHANDLER's catalogue gives no period. One noticeable feature is that the maximum of 1890 September 29 is 0.8 magnitude brighter than the maximum of 1889 December 21. This star at its minimum is probably fainter than the 16 magnitude.

Madison, Wisconsin, 1891 *November* 9.

ADDITIONAL NOTE ON THE ORBIT OF THE DOUBLE STAR Σ186.

By Prof. S. GLASENAPP.

In collecting the observations of Σ186 (*Astronomical Journal*, vol. XI, no. 6) for examination of the orbit, I have overlooked the observations made by Messrs. F. P. LEAVENWORTH and FRANK MULLER, at the Leander McCormick Observatory in 1886 (*Publications* of this Observatory, vol. I, p. 4).

The mean of four nights is,

$$1886.78 \qquad \theta = 206°.6 \qquad \rho = 0''.41$$

If we add this observation to the last normal position, its residual error will be considerably reduced. Indeed, it will be

$$1888.59 \qquad \theta_o = 212°.4 \qquad \rho_o = 0''.56$$
$$\theta_c = 211.9 \qquad \rho_c = 0.43$$
$$\theta_o - \theta_c = -2.5 \qquad \rho_o - \rho_c = -0.13$$
$$\text{instead of} \quad -3.4 \qquad\qquad -0.14$$

St. Petersburg, 1891 *Oct.* 16.

OBSERVED MAXIMA AND MINIMA OF SHORT-PERIOD VARIABLES IN *SAGITTARIUS*, WITH A NOTE ON THE ELEMENTS OF *Y SAGITTARII*.

By PAUL S. YENDELL.

6368. *X Sagittarii.*

The season's observations of this star, from June 7 to Sept. 20, 1891, number 35; the indicated times of apparent maxima and minima are

Maxima	w	Minima	w
1891 June 7.3	2	1891 June 26.4	1
15.4	1	July 23.3	2
22.6	2	31.3	1
July 7.4	1	Aug. 13.0	1
13.9	1	22.0	2
27.5	4	Sept. 1.5	2
Aug. 10.3	3		
24.9	1		
30.2	2		
Sept. 7.1	4		
21.8	1		

6172. *W Sagittarii.*

From 1891 June 7 to Sept. 21, I obtained 39 observations of *W Sagittarii*, from which have been deduced the following times of apparent maxima and minima:

Maxima	w	Minima	w
1891 June 10.3	1	1891 June 7.0	1
25.5	2	July 8.0	1
July 3.0	3	22.8	2
11.5	3	30.8	2
17.4	1	Aug. 6.3	3
26.3	4	13.0	2
Aug. 2.5	3	Sept. 20.3	3
10.0	4		
24.8	3		
Sept. 9.8	1		

6573. *Y Sagittarii.*

I have for the season, 38 observations from 1891 June 7 to Sept. 21. The indicated times of maxima and minima are

Maxima	w	Minima	w
1891 July 5.2	3	1891 July 13.3	2
9.7	3	25.0	1
16.3	2	31.3	3
27.5	2	Aug. 6.3	3
Aug. 3.0	2	22.1	1
8.4	3		
13.4	1		
25.3	3		

6636. *U Sagittarii.*

The season's observations number 28, from June 25 to Sept. 20. The following times of maxima and minima are indicated:

U Sagittarii.

Maxima	w	Minima	w
1891 July 5.1	2	1891 June 25.4	1
13.0	4	July 23.0	2
27.5	3	31.4	1
Aug. 2.2	2	Aug. 13.3	1
7.2	2	20.1	1
Sept. 6.6	2	Sept. 2.7	3
11.4	1	8.9	3
17.7	2	22.1	2

The comparison of the above results with the elements published by CHANDLER in his catalogue do not indicate any appreciable correction to the elements of *X* and *W*. In those of *U* also, in view of the color of the star and the personal differences of observers, it does not seem probable that any real discrepancy exists. In the case of *Y*, however, the persistence and gradual increase of the positive residuals since the middle of the summer of 1888, indicate that too small a value has been assigned to the period.

The variability of this star was detected by SAWYER in 1866, and published by him in this Journal, Vol. 7, p. 3; provisional elements and observed times of maxima and minima were published by him on p. 29 of the same volume. CHANDLER published elements, presumably of a more definitive character, in his Catalogue of Variables (*A. J.*, Vol. 8, pp. 88–89), in which the star is No. 6573.

I have kept this variable under as constant watch as practicable since 1888 June 13; the results of three seasons' work, those of 1888, 1889 and 1890, have already been published (*A. J.*, Vols. 8, 9 and 10).

Since the middle of the season of 1888, the residuals obtained from comparison of my observations with CHANDLER's elements, have been, with only two exceptions, positive, and gradually increasing, until the mean residual for the present season is $+1^h.3$.

Taking my own times of maxima and minima, pr

as above alluded to, in this Journal, (Vol. 8, p. 120, Vol. 9, p. 133, and Vol. 10, p. 117), together with those of this season, above enumerated, and SAWYER's published results for 1886 (Vol. 7, p. 29), we have a series, continuous, except in the year 1887, of fifty-five maxima and thirty-seven minima; comparing these observed times with CHANDLER's elements referred to above (1886 Sept. 25.31 + $5^d.7690\,E$), and treating the residuals derived by such comparison from the observed maxima, by the method of least squares, we obtain the following corrections to the elements.

To the Epoch. $-0^d.347 \pm 0^d.033 = -8^h\,20^m \pm 17^m\,30^s$
To the Period. $+0^d.0017 \pm 0^d.00042 = +6^m\,19^s \pm 36^s$

Treating in a similar manner the residuals derived from the observed times of minimum, we have corrections as follows:

To the Epoch. $-0^d.376 \pm 0^d.006 = -9^h\,2^m \pm 8^m\,38^s$
To the Period. $+0^d.0034 \pm 0^d.0001 = +5^m\,0^s \pm 8^s.6$

The very fair correspondence of these results with each other, and with a graphic plot of the yearly mean residuals, together with the relatively small probable errors indicated, would seem to show that the corrections are real.

Dorchester, Mass., 1891 *November* 17.

NEW ASTRONOMICAL WORKS.

Prize Essay on the Distribution of the Moon's Heat and its Variation with the Phase, by FRANK W. VERY, *of the Allegheny Observatory, U.S.* Published by the Utrecht Society of Arts and Sciences. 1891.

This investigation was made with a Langley's bolometer, together with a sensitive galvanometer. A concave mirror of silvered glass was made to throw an image of the moon, about 3 cm. in diameter, upon a white card, on which the details of the lunar surface could be easily recognized. A circular aperture in this card permitted the sensitive surface of the bolometer to be exposed; this having an area of about 19 mm² which corresponded to somewhat more than a thirtieth part of that of the apparent disc. The portion of the image to be examined was thrown upon the sensitive surface by adjustment of the siderostat, and kept there by the clockwork.

A blackened copper screen, containing water at a known temperature was placed in the path of the reflected light, at a sufficient distance from the mirror, and so arranged that it could easily be drawn aside, or replaced, by the observed at the galvanometer.

The observations consisted in readings from the moon, intermediate between two from the screen; and comparisons were also made on each evening between the radiation from the screen and that from the sky. Mr. VERY states that the bolometer and galvanometer employed are capable of giving repeated measures for a source of unchanging radiation, with an error of less than one per cent. of the measured quantity.

The several measurements are referred to the zenith by means of a table, given in the memoir.

In this way numerous measurements of the lunar heat were made for various portions of the surface. These observations are given for eight nights during the first four months of the year 1889, and the results are so tabulated as to permit general inferences at a glance, as well as mapped in an extended series of charts.

The author calls attention to the fact that while previous investigations have dealt with the total lunar radiation, these researches have been directed to the study of that from numerous small portions of the disc, thus affording many and interesting additional data.

Lunar Radiant Heat, measured at Birr Castle Observatory, during the total eclipse of January 28, 1888. By OTTO BOEDDICKER, *Ph.D. With an Introduction by the Earl of Rosse.* From the Transactions of the Royal Dublin Society.

This investigation stands in an interesting relation to the very different one made by Mr. VERY. For some twenty or more years, Lord ROSSE had endeavored to determine the radiant heat of the moon, receiving the lunar image, from his great reflector upon a smaller concaved mirror, in the focus of which was placed a thermopile. Repeated experiments were made in this way, under varied conditions, but were not found fully satisfactory, although some approximate determinations were attained, as to the ratio between lunar and solar radiation. The most important deduction was, that the moon's heat contained a much larger proportion, than the sun's, of rays of low refrangibility.

In 1869–70 these investigations were resumed, under Dr. COPELAND, using the same apparatus, newly refitted. The results were similar, but more trustworthy, and included the fact that the maximum of heat radiated from the moon was not subsequent to the maximum of illumination.

Attempts were made in 1872 and in 1884 to determine the variation of thermal radiation from the moon during an eclipse; but the first thoroughly favorable opportunity offered itself in January, 1888. The eclipse was total, and the sky unobscured. The observations of Dr. BOEDDICKER are here given in detail, together with his deduced theoretical curves for the moon's light and heat. He considers it demonstrated that the radiated heat began to diminish long before the first contact with the penumbra. The diminution, which seemed to be indicated much earlier, had definitely set in at least three minutes before this contact, — which would imply the existence of a heat-absorbing terrestrial atmosphere not less than 300 kilometers high.

He found the decrease of the heat to be more rapid than that of the light as the penumbra advanced upon the lunar disc, and the heat-curve to intersect the light-curve at 26m.7 before totality; that is to say, the heat emitted then began to exceed the reflected heat. The probable thermal minimum was found to be about two minutes previous to the end of totality.

Sundry hypothetical explanations of these and other phenomena are fully discussed, and attention is called to the fact that the varying radiation of different parts of the lunar surface requires systematic observation. This requirement has already been fulfilled, to a considerable extent, by Mr. VERY's investigation.

CONTENTS.

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CAPTURE OF COMETS BY PLANETS,

BY H. A. NEWTON.

In a paper published in 1878 I obtained a simple expression for the change of energy of a small body, a comet for example, that passes near enough to a large planet to have its orbit so seriously changed that all the minor terms in the perturbations may be disregarded. The great interest recently shown in this particular problem of perturbation has led me to take up again the formula, and deduce some results that logically follow from it. The details of the algebraic work are given in a paper in the *American Journal of Science* [3] vol. XLII, Sept. and Dec., 1891. Some of the principal results are given below. Most of the computations made refer to the case of comets moving originally in parabolic orbits about the sun, and passing very near to the planet *Jupiter*, though small changes will make the reasonings apply equally to other comets and planets.

1. The different ways in which such comets can approach *Jupiter* may, by disregarding the plane of *Jupiter's* orbit about the sun, be treated as depending on three independent variables. Let d be the shortest distance between the orbit of the planet and the unperturbed orbit of a comet, ω the angle between the two tangents to those orbits at the extremities of d, and h the distance *Jupiter* has yet to travel to reach one end of d at the moment when the comet would if unperturbed be at the other end of d. The elements of a given cometic orbit, along with the elements of *Jupiter's* orbit, furnish easily the corresponding values of d, ω and h.

2. The loss of energy during the whole transit of the comet past the planet is capable of expression in terms of d, h and ω. Hence the semiaxis major of the elliptic orbit after large perturbation may be expressed in terms of the same three quantities. In other words, the elements of the orbits of the comet and the planet before perturbation furnish the means of computing directly and simply the periodic time of the comet after a large perturbation.

3. If m is the mass of the planet, r its distance from the sun, and if s, Δ and θ are functions of ω defined by the equations $s^2 = 3 - 2\sqrt{2}\cos\omega$, $\Delta = \frac{mr}{s^2}$ and $2s\cos\theta = 1 - s$, then the equation

$$a = \frac{s}{4m} \cdot \frac{\Delta^2 + d^2 + h^2\sin^2\theta}{\Delta\cos\theta + h\sin^2\theta}$$

gives a the semiaxis major of the elliptic orbit of the comet about the sun after perturbation: if a is negative it is the half of the transverse axis of the resulting hyperbolic orbit.

4. For a given value of ω and a given positive value of a the two quantities d and h can be treated as the abscissa and ordinate of an ellipse. For values of d and h corresponding to points within the ellipse a is smaller than for values of d and h corresponding to points upon or outside of the ellipse. As a varies the ellipses constitute a *faisceau* of similar and similarly situated ellipses having the straight line $\Delta\cos\theta + h\sin^2\theta = 0$ for their common radical axis. For points above the radical axis the final orbit is an ellipse, for points below it is an hyperbola.

5. The greatest effect of perturbation of a planet moving in a circular orbit in shortening the periodic time of a comet moving originally in a parabola is obtained if the comet's original orbit actually intersects the planet's orbit at an angle of 45°, and if the comet is due first at the point of intersection at the instant when the planet's distance therefrom is equal to the planet's distance from the sun multiplied by the ratio of the mass of the planet to the mass of the sun. The relative velocity of the comet on leaving the planet's sphere of action, would be equal to and directly opposite to the planet's velocity, and the comet would be left entirely at rest to fall to the sun.

6. In order to facilitate the consideration of the effect of a planet upon comets as a group two arbitrary assumptions have been made relative to the distribution of the comets themselves, and the distribution of the directions of their motions.

> (*a*) If about the sun as a center a spherical surface S be described with an arbitrary radius, it is assumed that near S space is filled equally with comets.
>
> (*b*) It is further assumed that the directions of the comets in each cubic unit of space near S are at random; that is, that the quits and goals of the comets' motions relative to the sun are distributed equally over the surface of the celestial sphere.

So far as these assumptions are not true in nature, so far modifications of conclusions resting upon them will need to be made.

7. It follows from the assumptions of (6) that if comets be grouped according to their perihelion distances the number of comets whose perihelion distances are less than q is proportional to q.

8. If the two assumptions are true for a spherical surface S, they will be true for every smaller concentric surface.

9. It also follows that if r is the planet's distance from the sun, and r' is small relative to r, the number of comets which, in a given period of time come nearer to the sun than r is to the number that (unperturbed) come nearer to the planet than r' as $6r^2$ is to $7r'^2$. The factor $\frac{7}{6}$ expresses the increase of numbers caused by the planet's motion in its circular orbit.

10. The number of comets which in a given period of time pass their perihelia nearer to the sun than a given planet, is to the number of comets whose periodic times are reduced by the perturbing action of the planet so as to be less severally than one-half, once, three-halves, and twice, the periodic time of the planet, as unity is to the square of the mass of the planet multiplied severally by 0.139, 0.925, 1.876 and 2.913.

11. With the same assumptions, and regarding the planet as without dimension so as to intercept any comets, if in a given period of time a thousand million comets come in parabolic orbits nearer to the sun than *Jupiter*, 126 of them will have their orbits changed into ellipses with periodic times less than one-half that of *Jupiter*; 839 of them will have their orbits changed into ellipses with periodic times less than that of *Jupiter*; 1701 of them will have their orbits changed into ellipses with periodic times less than once and a half-times that of *Jupiter*; and 2670 of them will have their orbits changed into ellipses with periodic times less than twice that of *Jupiter*.

12. Of the 839 comets whose periodic times after perturbation are less than *Jupiter's* period, 203 will after perturbation have retrograde motions, and 636 will have direct motions. Also 267 of them will have quits less than 45° from *Jupiter's* quit, while 38 of them will have quits less than 45° from *Jupiter's* goal. Also 257 of them will move in orbits whose planes are inclined less than 30° to *Jupiter's* orbit, while 51 will move in orbits inclined more than 150° to *Jupiter's* orbit.

13. Each comet has been thus far considered as approaching *Jupiter* while moving in a parabolic orbit about the sun. If the comet however is moving in any other orbit, and it passes near to the planet, the result of the planet's perturbing action will in general be quite similar to the result when the orbit is parabolic, the other circumstances of the approach being assumed to be alike in the two cases.

The above conclusions refer moreover to perturbations during one transit of the comet past the planet. But the comet, unless the orbit is further changed by another planet, must return at each revolution to the place where it encountered *Jupiter*. At some time *Jupiter* will be nigh that place nearly at the same time as the comet, and the comet will suffer a new, and perhaps a large perturbation. Its period will again be changed, being shortened or lengthened according as the comet passes before or behind the planet. This process will be repeated again and again, since after any number of encounters the new orbit of the comet will still pass near to the orbit of the planet.

This repeated action makes it possible, and even usual, to have an orbit shortened in period by several passages near to *Jupiter* instead of its being done at one passage. A much larger proportion of comets than 839 out of 1,000,000,000 must therefore have their periodic times reduced below the period of *Jupiter*.

If the comet's orbit is largely inclined to the ecliptic, and hence its motion makes a large angle with that of *Jupiter*, there is nearly an even chance that the velocity will be increased or diminished. A considerable fractional part of the whole number of such comets will at each passage be thrown out of the solar system altogether, or thrown into such long orbits that they will return only at very great intervals of time. This class of comets cannot be therefore regarded as permanent members of the family of short period comets, except such of them as happen to come so near to other planets as to have their orbits changed in such wise that they do not have thereafter the near approach to *Jupiter's* orbit. But when an orbit is greatly inclined to the plane of the solar system the comet passes through the plane in general at a considerable angle, and the chance of coming close to another planet is relatively small.

On the other hand, all the comets which after perturbation are moving in orbits somewhat, but not greatly inclined to the ecliptic, are liable to meet, (in fact, are sooner or later almost certain to meet) other planets in such a way as to suffer perturbations that will prevent future close encounters with *Jupiter*. After such changes those comets must be regarded as tolerably permanent members of the solar system.

Comets that have motions not greatly inclined to *Jupiter's* motion are more likely in subsequent passages near to *Jupiter* to have their periodic times shortened than lengthened. On the contrary, those passing in nearly opposite direction to *Jupiter's* motion will be quite sure to have their periods lengthened rather than shortened.

All these causes combine and work together to the one end that those comets which are changed by the perturbing action of *Jupiter*, or other planets, from parabolic orbits of every possible inclination to the ecliptic into short period ellipses, and become permanent members of the solar system, will as a rule (but with exceptions) move in orbits of moderate inclination to the ecliptic, and with direct motions.

We know as a fact, that most short period comets do move in orbits having small inclinations and direct motions,

while long period and parabolic comets move at all possible inclinations to the ecliptic. If the short period comets have been changed by *Jupiter* and other planets from parabolic orbits, the preceding investigation shows why their orbits have now small inclinations to the ecliptic, and the comets themselves have direct motions.

FILAR-MICROMETER OBSERVATIONS OF COMET 1889 IV,

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY,

BY E. E. BARNARD.

1889 Mt. Hamilton M.T.	✱	No. Comp.	☄′ — ✱ $\Delta\alpha$	☄′ — ✱ $\Delta\delta$	☄′'s apparent α	☄′'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
d h m s			m s	′ ″	h m s	° ′ ″		
Aug. 21 8 18 19	4	16 , 6	—0 10.11	+1 7.3	15 51 54.14	+20 22 56.1	9.480	0.491
27 8 19 21	5	10 , 6	+0 50.48	—1 27.5	16 7 44.94	+23 15 39.6	9.594	0.489
Nov. 11 8 21 3	6	6 , 1	—3 23.73	+2 2.4	18 15 44.21	+37 13 5.0	9.760	0.529
15 7 47 52	7	12 , 6	—0 23.95	—3 11.6	18 17 46.94	+37 19 33.8	9.743	0.447

Mean Places for 1889.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
4	15 52 3.36	+0.86	+20 21 38.2	+10.9	W.B. XV, 1262
5	16 6 53.66	+0.80	+23 16 55.0	+12.1	W.B. XVI, 155
6	18 19 8.01	—0.07	+37 10 46.9	+15.7	W.B. XVIII, 1471–2
7	18 48 10.96	—0.10	+37 23 1.0	+14.1	Lal. 35238, 9

ON THE VARIATION OF LATITUDE,

BY S. C. CHANDLER.

III.

Before proceeding to discuss the older observations, which it was intimated in no. 249 would follow in this number, it is desirable to pursue the topic of p. 70 a little further. I therefore select from the various investigations on hand, and which will appear in due course, two which pertain to the same period, 1863–1867, covered by the Pulkowa and Washington series, — namely Melbourne and Leyden. These will offer an entirely independent verification of the deductions drawn. The Melbourne discussion extends from 1863 to 1884, and is to be given in full in its proper order in these articles. I can therefore spare but a few lines here in description of the method adopted in its treatment. It is based on 36 southern circumpolar stars observed with the transit-circle. For each of these stars the mean values of the observed polar distances were computed for each month during the twenty-one years, and reduced to the epoch 1870.0 by means of Dr. GOULD's proper motions and precession-coefficients (*Cordoba Observations*, Vol. V, *Introd.* pp. xxxii–cxxxix). The results for both culminations were then combined so as to eliminate the error of the latitude assumed in the reduction of the observations, and a series of residuals obtained representing the deviations (O—C) of the observed latitudes for each month from the mean value given by the whole series of twenty-one years. That portion of the series for the interval 1863–1867 June was then treated exactly like the Pulkowa and Washington series on p. 70, giving the column *O*, on p. 76.

For Leyden, I employed the meridian altitudes of *Polaris* on pp. 227–231, Vol. II, *Leyden Annals*. Taking monthly means, reducing to 1866.0, applying the appropriate correction for division-errors and flexure, in the different positions of the instrument, for both culminations, and for each circle, and reducing the reflected observations to the center of the instrument, we get the following observed latitudes, and the deviations, O—C, from an assumed value 51° 9′ 19″.90.

Date	Observed φ	O—C	Wt.
	° ′ ″	″	
1864 May	51 9 20.02	+0.12	11
June	19.98	+ .08	18
July	19.66	— .24	4
Sept.	19.91	+ .01	34
Oct.	19.83	— .07	58
Nov.	20.16	+ .26	4
1865 Feb.	19.54	— .36	8
Mar.	19.63	— .27	16
Apr.	19.83	— .07	74
May	19.67	— .23	80
Sept.	51 9 20.00	+0.10	66

Date	Observed φ	O—C	Wt.
	° ′ ″	″	
1865 Oct.	51 9 19.91	+0.01	24
Nov.	20.07	+ .17	24
Dec.	20.22	+ .32	1
1866 Mar.	20.04	+ .14	26
Apr.	19.70	— .20	4
May	19.86	— .04	40
June	19.93	+ .03	26
Oct.	19.91	+ .01	38
Nov.	13.71	— .19	2
1867 Apr.	20.14	+ .24	8
Sept.	20.10	+ .20	12
Oct.	19.78	— .12	10
Nov.	19.87	— .03	10
Dec.	19.43	— .47	8
1868 Mar.	20.01	+ .11	20
Apr.	20.14	+ .24	24
May	20.00	+ .10	120
June	51 9 20.04	+0.14	4

Assembling the above residuals in the same way as for previous series, we have the column O for Leyden, below.

	t	Obs.	O	C
			″	″
Melbourne	2402630	66	+0.07	+0.04
	2693	51	+ .23	+ .21
	2751	47	+ .33	+ .21
	2828	125	+ .09	+ .01
	2880	118	+ .16	— .15
	2940	83	+ .04	— .23
	2402992	101	—0.04	—0.16
Leyden	2402407	50	—0.10	—0.13
	2451	108	+ .03	.00
	2502	96	+ .06	+ .16
	2556	78	+ .09	+ .23
	2604	190	+ .09	+ .18
	2676	50	+ .05	— .04
	2747	82	— .06	— .21
	2402786	166	—0.13	—0.22

If now the assumed law of variation of latitude, and the constants determined from the Washington–Pulkowa series, are real, they should represent the above observed values, O, for Melbourne and Leyden, at least substantially. Accordingly, taking as before, $r = 0''.23$, $T = 2402338$, $\theta = 0^\circ.843$, and λ, $-4^\circ.5$ for Leyden, and $-145^\circ.0$ for Melbourne, in the equation $\varphi - \varphi_0 = -r\cos[\lambda + (t-T)\theta]$, we get the computed values in column C above. It will be seen that the formula assigns the times of maximum and minimum latitudes with a fidelity which it would be unreasonable to regard as fortuitous. The range, dependent on the value of r used, does not so well accord with the observed values, especially for Leyden. It should be noted, however, that this observed range is much greater in the table of the monthly mean latitudes for Leyden, previously given. This circumstance is one among many which lead me to believe, as I have already intimated on p. 65, that the polar rotation is not perfectly regular from period to period. The fuller discussion of this matter is necessarily deferred until I have presented all the investigations, from the time of Bradley up, when it will be undertaken in connection with the secular changes in the rotation-period, which these yet unprinted investigations seem to establish beyond question.

Meanwhile I desire to remark that the admirable way in which the hypothesis embodied in the above formula, with its yet imperfectly determined constants, reconciles the observed discordances of latitude at points of the earth's surface separated by 220° longitude and 97° latitude, demonstrates that the phenomena are neither instrumental, local, nor regional, but are terrestrial.

Before leaving the Leyden series, it is interesting to point out how completely this hypothesis accounts for the contradictory results obtained by Dr. Van Hennekeler in the attempt to trace the influence of temperature in the latitude of the Leyden circle. He found (*Leyden Annals*, II, p. 116),

Spring of 1865 and 1866, $\varphi = 52^\circ\ 9'\ 19''.77$
Autumn of 1865, 20 .00

On the other hand, he found that the above spring value agreed with the autumn value of 1867, and the above autumn value agreed with that in the spring of 1868. Hence the evidence as to temperature was contradictory.

The above formula gives for these various epochs,

	″		° ′ ″
Spring of 1865	19.67	mean	52 9 19.72
Spring of 1866	19.77		
Autumn of 1865			20.10
Autumn of 1867			19.75
Spring of 1868			20.11

thus a complete correspondence with the observed results. It should be borne in mind, too, that the constants from which these values are computed (except the mean value $\varphi_0 = 52^\circ\ 9'\ 19''.90$) were derived, not from the Leyden observations, but from those at Washington and Pulkowa.

I now proceed to set forth, as nearly as convenient in chronological order, the researches pertaining to the more important series of observations in modern astronomy suitable for our present purpose. First, are the observations of Bradley; at Kew (1726–27) with Molyneux's zenith-tube; at Wanstead (1727–47) with the new zenith-sector; at Greenwich (1750–54) with the same instrument; and finally at Greenwich (1750–62) with Bird's so-called new mural quadrant. Of these the series at Wanstead is by far the most important for our present aim. Bradley's original papers pertaining to these observations were discovered by Prof. Rigaud, and published in 1832, and their reduc-

tion by Busch appeared in 1838. I have reduced them anew, retaining Bessel's precession-constant, but employing Peters's nutation and Struve's aberration-constant, and Boss's and Auwers's proper motions. The correction of Busch's reduction-tables, which were based on Lindenau's nutation and Delambre's aberration, has been effected by the use of the factors +0.00938 for the aberration, +0.0271 for the lunar nutation, and −0.0524 for the solar nutation. The 2☾-term has been included, but not the terms depending on the solar and lunar perigees. In the definitive discussion I shall of course use all of the 23 stars observed by Bradley, but for this preliminary paper I use only 10 stars, selecting all within a degree of the zenith (except 9 *Aurigae*, observed only 21 times), and, for the purposes of control in regard to certain questions that will arise, 2 stars north and 2 south, from 3° to 5° distant from the zenith. The distribution of these stars and observations is shown in the following table:

Star	Obs.	α 1730	ζ	C
		h m	′	° ′ ″
α *Cassiopeae*,	101	0 24	−3 31	31 55 23.11
τ *Persei*,	51	2 35	−0 9	38 20 28.48
γ *Persei*,	51	2 45	−0 57	37 33 6.12
α *Persei*,	61	3 5	+2 36	41 6 10.72
– *Camelopardalis*,	40	5 13	−0 3	38 27 12.65
ζ *Ursae Majoris*,	125	13 13	−4 52	33 37 39.53
η *Ursae Majoris*,	149	13 37	−0 48	39 18 8.66
β *Draconis*,	240	17 21	−1 2	37 27 31.90
ι *Herculis*,	63	17 32	+5 19	43 48 29.60
γ *Draconis*,	290	17 50	−0 3	38 26 21.98

This preliminary inquiry therefore comprises more than half of Bradley's observations. In the last column, *C*, is the mean value of the instrumental polar distance, assumed as hereafter explained. In the following table are given the values of O—C, presenting the deviations from these values of *C*, of the observations taken in groups indicated by the first two columns, after their reduction to 1730.0 as above described.

α Cassiopeae.

			″				″
27	Sept. 17	5	+0.63	29	June 16	4	0.00
	Oct. 7	5	+ .55		June 21	1	+ .39
	Nov. 27	5	+ .41		Oct. 21	3	— .33
	Dec. 29	5	— .12		Dec. 14	7	— .79
28	Feb. 1	6	+ .51	30	June 23	3	+0.31
	Apr. 25	1	— .42		Dec. 29	1	—1.63
	July 1	5	— .29	32	Apr. 28	1	—0.44
	Aug. 3	4	+ .64	33	Jan. 21	2	+ .77
	Sept. 28	4	+ .50	34	June 24	2	+ .56
	Nov. 8	1	— .26	35	Jan. 1	3	— .41
	Dec. 9	6	+ .17	39	Jan. 6	2	—0.20
	Dec. 24	5	— .38	40	June 13	1	+1.86
29	Feb. 28	3	— .01	17	Mar. 10	1	+0.90
	Apr. 5	3	+0.77				

τ Persei.

			″				
27	Oct. 4	3	—0.20	29	Aug. 30	3	+0.10
	Nov. 26	3	+0.20		Dec. 11	1	—1.10
28	Jan. 13	4	+1.09	30	Feb. 11	1	+0.25
	Feb. 14	1	+0.82	31	Jan. 16	3	— .16
	Aug. 19	5	+ .50	32	Jan. 15	3	— .04
	Nov. 13	3	— .68	33	Feb. 1	1	+ .32
	Dec. 10	4	— .62	39	Jan. 1	1	+0.32
29	Jan. 24	5	—0.59	40	Feb. 2	1	+1.75

γ Persei.

			″				
27	Oct. 26	2	+0.32	29	Aug. 10	5	—0.29
28	Jan. 15	5	+ .29		Dec. 12	3	— .11
	Feb. 17	5	+ .73	30	Feb. 11	1	.00
	Aug. 7	4	+ .34	31	Jan. 16	3	— .31
	Nov. 21	5	— .28	32	Jan. 12	2	— .96
	Dec. 22	5	— .73	39	Jan. 4	1	+ .16
29	Jan. 18	3	— .28	40	Feb. 1	2	+0.77
	Mar. 8	2	+0.24				

α Persei.

27	Nov. 12	2	+0.13	29	Aug. 10	5	—0.78
28	Jan. 9	3	+ .89		Dec. 14	1	— .12
	Feb. 20	5	+ .50	30	Feb. 11	1	+ .21
	Apr. 26	4	+ .32		July 26	1	+ .55
	July 16	5	—0.16	31	Jan. 16	3	+ .76
	Aug. 10	4	—1.05	32	Jan. 11	2	+ .86
	Nov. 21	5	—0.82	34	July 7	2	— .39
	Dec. 22	5	— .75	39	Jan. 1	2	+0.78
29	Feb. 13	4	+ .18	40	Feb. 1	2	+1.11
	July 8	5	+0.05				

— Camelopardalis.

			″				
27	Oct. 17	3	—0.41	29	Oct. 7	5	—0.01
	Dec. 19	3	+ .12		Dec. 21	1	—0.74
28	Jan. 31	4	— .47	30	Mar. 14	1	+1.06
	Feb. 14	4	+ .32	31	Feb. 16	1	—0.08
	Mar. 7	4	+ .76	39	Feb. 4	5	— .52
	Oct. 4	3	— .21	40	Jan. 31	1	+0.89
29	Feb. 21	4	—0.18	47	Mar. 10	1	+2.00

ζ Ursae Majoris.

			″				
27	Oct. 23	5	—0.03	31	Jan. 11	2	—1.59
	Nov. 19	6	— .16		Sept. 10	3	+1.02
	Dec. 26	4	— .16		Oct. 2	1	+0.18
28	Feb. 12	3	— .24	32	Jan. 18	3	—2.17
	Apr. 20	5	— .83		Sept. 11	1	+0.15
	June 7	5	+ .11	34	July 1	1	+1.12
	July 9	5	+0.12		Aug. 3	1	+0.18
	Aug. 26	5	+1.58	35	Sept. 24	1	+1.43
	Oct. 19	5	+0.85	36	Sept. 21	2	—0.27
29	Jan. 6	1	— .54	37	July 10	2	+0.59
	Feb. 5	3	— .55		Sept. 17	1	+1.91
	Apr. 19	5	+ .34	38	July 8	4	—0.73
	June 6	5	— .13	39	May 4	3	—0.97
	July 7	5	+ .27	40	June 11	7	+3.37
	July 23	1	—0.03	41	Sept. 24	1	+3.05
	Oct. 24	1	—1.17	42	Sept. 17	1	+3.27
30	Aug. 6	3	+1.70	46	Oct. 1	2	+1.15
	Sept. 13	3	+0.39	47	Sept. 13	1	+0.81

η Ursae Majoris.

			″				″
27	Oct. 10	7	+0.51	32	Jan. 18	3	—0.67
	Nov. 19	6	+ .12		Apr. 26	2	+1.01
28	Jan. 21	6	— .22	34	June 25	4	+0.31
	Apr. 26	6	— .98		July 22	4	+ .01
	June 22	6	— .16		Aug. 10	3	+ .07
	July 13	5	— .27	35	Sept. 20	2	+0.73
	Aug. 27	5	+ .66	36	Sept. 21	2	—1.10
	Oct. 11	5	+ .74	37	July 11	4	—0.85
	Dec. 5	6	— .19		Sept. 17	1	+0.27
29	Feb. 3	5	— .20	38	July 11	5	—2.13
	Apr. 28	5	— .79		Oct. 4	1	—0.30
	June 14	5	— .70	39	May 4	3	—1.74
	July 9	5	— .21		Sept. 14	1	+1.67
	Sept. 8	3	+ .15	40	June 14	8	+0.65
	Oct. 25	4	— .05		Sept. 27	3	+ .58
30	Aug. 19	7	+0.69	45	Sept. 16	1	— .35
31	Jan. 11	2	+1.01	46	Oct. 1	2	+0.19
	Aug. 23	1	—1.15	47	Sept. 13	2	+1.03
	Sept. 30	6	+0.57				

β Draconis.

			″				″
27	Sept. 2	5	+0.31	31	Aug. 28	7	+0.96
	Sept. 17	5	+ .89		Sept. 21	6	+1.07
	Oct. 30	5	+ .53		Oct. 5	5	+1.61
	Dec. 27	5	+ .54		Dec. 29	1	+0.01
28	Feb. 10	5	+ .51	32	Sept. 15	5	+1.64
	Mar. 29	5	— .63	33	Feb. 2	1	+0.11
	May 6	5	— .25		Sept. 7	3	— .21
	July 2	5	— .83	34	July 13	5	+ .63
	July 20	5	— .44		Aug. 15	6	+ .16
	Aug. 11	5	+ .35	35	Jan. 1	1	— .83
	Aug. 26	5	+ .18		Sept. 22	2	+ .74
	Sept. 11	6	— .10	36	Sept. 17	3	— .05
	Oct. 1	6	+ .29	37	Jan. 22	2	— .70
	Dec. 9	5	+ .06		Sept. 16	6	+ .60
29	Feb. 12	6	— .74	38	Aug. 19	4	— .74
	Mar. 10	5	—0.97	39	Feb. 4	1	— .37
	Apr. 1	5	—1.34		Sept. 6	9	+ .25
	June 13	5	+0.41	40	Jan. 31	1	— .57
	Aug. 1	6	+ .30		Aug. 30	6	+0.47
	Aug. 20	5	+ .04		Sept. 17	5	+1.36
	Sept. 6	6	+ .53	41	Feb. 6	1	+0.29
	Sept. 29	5	+ .47		Sept. 11	7	+ .85
	Nov. 8	6	+ .39	42	Sept. 16	2	+ .82
30	Mar. 25	2	— .96	43	Sept. 11	2	+0.98
	June 17	2	— .63	45	Sept. 14	2	+2.40
	Sept. 3	5	+ .91	46	Sept. 29	3	+0.46
	Sept. 26	1	+ .18	47	Sept. 12	2	+2.80
31	Jan. 2	5	—0.14				

ι Herculis.

			″				″
28	Mar. 25	5	+1.11	29	July 14	5	—0.35
	May 10	1	+0.36		Aug. 15	5	— .06
	June 21	5	+ .34		Aug. 30	6	+ .88
	July 23	5	—0.21	30	Mar. 26	3	— .67
	Aug. 14	5	—1.01		June 18	2	+ .50
	Aug. 27	6	—0.77		Sept. 1	5	+0.72
29	Mar. 21	7	—0.88				

γ Draconis.

			″				″
27	Sept. 7	10	+0.22	27	Dec. 10	5	+0.45
	Oct. 1	7	+ .28	28	Jan. 13	4	+ .44
	Oct. 26	4	+0.68		Feb. 14	4	+0.11

γ Draconis. — (Cont.)

			″				″
28	Apr. 1	6	—0.72	32	Sept. 15	5	+0.29
	June 5	5	— .19	33	Feb. 1	2	— .17
	July 13	7	— .45		Sept. 7	3	+ .16
	Aug. 23	8	+ .38	34	June 13	5	— .27
	Sept. 9	7	+ .27		Aug. 16	5	— .04
	Sept. 26	8	+ .23	35	Jan. 1	4	+ .21
	Nov. 12	5	+ .14		Sept. 22	3	+ .83
	Dec. 23	6	+ .13	36	Sept. 6	3	— .29
29	Feb. 16	7	— .28	37	Jan. 20	3	— .61
	Mar. 11	7	— .91		Sept. 18	6	— .15
	Apr. 5	4	— .69		Dec. 23	1	—0.15
	June 17	4	.00	38	Aug. 7	3	—1.94
	July 10	1	— .22		Sept. 24	6	—1.14
	Aug. 16	8	+ .20	39	Jan. 21	4	—0.29
	Sept. 6	8	— .06		Sept. 1	5	— .02
	Sept. 27	5	+ .27		Sept. 10	5	+ .05
	Nov. 22	5	+ .28	40	Feb. 3	2	+ .17
	Dec. 18	5	+0.15		Aug. 31	6	— .09
30	Mar. 26	3	—1.26		Sept. 16	6	+ .65
	June 17	2	—0.63	41	Feb. 6	1	— .08
	Sept. 2	6	+ .26		Sept. 9	5	+ .98
	Sept. 22	9	+ .31		Sept. 25	5	+0.97
	Dec. 30	5	— .01	42	Sept. 16	1	—1.40
31	Feb. 16	3	+ .06	43	Sept. 13	1	+0.18
	Aug. 30	7	+0.56	45	Sept. 14	3	+1.19
	Sept. 25	5	+0.69	46	Sept. 28	2	+0.34
	Oct. 6	6	+1.11	47	Sept. 12	3	+0.09
32	Jan. 10	3	+0.19				

Assuming the exactness of the constants of reduction, the above residuals involve : (*a*), the correction to the assumed instrumental polar distance; (*b*), the correction for refraction; (*c*), the correction for any unknown instrumental changes, either of the relation of the graduated arc to the telescope, or to differential flexure of the tube, as affected by the variations of the star's meridian-altitude, — or of the direction of the collimation-axis with regard to the plumb-line; and finally (*d*), any shifting of the instrumental zenith, as indicated by the plumb-line, and any stellar parallax.

As to (*b*), the average zenith-distance of the six stars in the zenithal group is only 0° 30′ so that the change of refraction corresponding to a range of temperature from 20° to 80° Fahrenheit is but ±0″.05, and even this unimportant quantity is partly eliminated by the distribution of the stars north and south of the zenith. For stars 3° from the zenith, the corresponding range of refraction is ±0″.30, but is almost entirely eliminated for the same reason. While in the final discussion I shall apply hypothetical refractions from assumed mean temperatures at different times of the year (Bradley having left no record), this can in no wise influence the result appreciably.

As to (*c*), the alteration of the relative length of the graduated arc due to the different temperatures of the upper and lower rooms through which the sector passed, even if appreciable — and I fail to trace it in the observations — is eliminated in the combination of north and south stars. As to flexure, it would be purely differential, and so far as the

changes of a star's altitude by precession and the lunar nutation are concerned, would confound itself with any slow changes in the line of collimation, and in no way conceal any evidence of periodic change in the latitude for which we are searching. The effect on flexure of aberrational change would indeed have an annual period, but would be eliminated by combining stars in opposite right-ascension, and hence would amount, even at 5° zenith-distance, to but an eight-hundredth part of the total flexure, or but a ten thousandth of the horizontal flexure.

There remains then only the possible variation in the line of collimation to be seriously considered.

FILAR-MICROMETER OBSERVATIONS OF COMET 1890 II.

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY.

BY E. E. BARNARD.

1890 Mt. Hamilton M.T.	✱	No. Comp.	☄ — ✱ Δα	☄ — ✱ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
d h m s			m s	′ ″	h m s	° ′ ″		
Mar. 30 16 31 52	3	18 , 6	+0 12.52	—3 56.6	21 10 59.46	+10 21 12.6	n9.620	[illegible]
31 16 16 50	4	10 , 6	+0 31.27	—8 53.6	21 11 3.24	+10 52 21.5	n9.631	0.667
Apr. 14 15 13 10	5	. . .	—0 0.36	0 0.0	. . . . .	. . . . . .	n9.654	0.617
30 16 15 59	6	11 , 3	—0 5.08	+1 19.9	21 0 33.00	+29 23 35.5	n9.155	0.540
May 16 12 3 44	7	3	. . . .	+1 6.7	. . . . .	+43 47.5	. . .	0.371
12 16 56	7	10	+1 34.85	. . . .	20 31 53.9	. . . . .	n9.783	. . .
June 22 9 31 40	8	8 , 6	—2 0.16	—6 50.4	15 46 57.73	+65 1 1.1	n8.663	n9.615
July 2 9 30 30	9	14 , 3	+1 53.47	+5 32.2	14 30 37.83	+60 48 23.8	9.623	n9.455
Aug. 10 9 28 43	10	12 , 6	—1 14.16	—5 25.9	13 4 20.4	+41 55.7	9.739	0.565
31 8 38 7	11	6	. . . .	—1 59.7	. . . . .	+35 22.1	. .	0.662
8 54 59	12	10	—1 39.01	. . . .	12 59 43.5	. . . . . .	9.756	. . .

Mean Places for 1890.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
3	21 10 48.02	—1.08	+10 28 21.8	—12.6	W.B. XXI, 189
4	21 10 32.99	—1.02	+11 1 28.0	—12.9	Lal. 41290
5	21 10 4±	—0.59	+18 25±	—11.4	9ᴹ.5, approximate from place of comet
6	21 0 38.21	—0.16	+29 22 31.6	—16.0	B.B. +29° 4301
7	20 30 18.8	+0.32	+43 46.7	—20.3	DM. 43° 3658
8	15 48 51.97	+2.92	+65 7 45.7	+ 6.1	Fedor. Lal. 2703
9	14 28 42.76	+1.60	+60 42 38.3	+13.1	Oeltz. Argel. 14660.
10	13 6 1.9	+0.04	+42 1.0	+ 9.8	DM. 42° 2379
11	13 1 22.6	—0.14	+35 27.0	+ 6.0	DM. 35° 2401

April 14. Position from the observation of an almost central occultation of a 9ᴹ.5 star.

ON THE PERIOD OF 466 *U PISCIUM.*

BY HENRY M. PARKHURST.

The formula which I gave in the *Astronomical Journal*, no. 235, accurately represented all the observations upon which it was founded. Yet it is apparent from the later and much more elaborate observations of Mr. TOWNLEY (*A.J.* no. 238), confirmed by my observations of the present year, either that the shortening of the period was temporary, or that it was illusive. The variable did not fall to 11ᴹ.5 until 16 days after the maximum just passed; so that it is not improbable that the maximum in 1884 was several weeks after the observations of Dr. PETERS. A uniform period of 171.8 days, derived from my observations in 1885 and 1891, produces the following results:

Computed	Observed
1884 Dec. 18	Nov. 20 ±
1885 Sept. 22	Sept. 22
1886 Sept. 1	Sept. 1
1889 Jan. 7	Dec. 23 ±
1889 Dec. 16	Dec. 20
1890 Nov. 25	Nov. 24
1891 Nov. 3	Nov. 3
1892 Oct. 12	—

This nearly corresponds with the elements given in the table in the *Astronomical Journal*, no. 216.

The disagreement between Mr. TOWNLEY's observation of Jan. 3, 1891, and my own on Jan. 9, was wholly due to the photometric scale employed. We both compared the variable with the same star, *t*, and both considered them equal in brightness. But he estimated *t* = 11.8; while I had deduced (from two observations only) *t* = 12.2, on the scale of the Harvard Photometry.

New York, 1891 *Nov.* 19.

OBSERVATIONS OF THE PERIODIC COMET OF WOLF (*b* 1891),

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 9.6-INCH EQUATORIAL,

BY PROF. E. FRISBY.

[Communicated by the Superintendent.]

1891 Washington M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
d h m s			m s	′ ″	h m s	° ′ ″		
Oct. 23 10 58 25.8	1	20 , 4	−2 28.38	+0 30.6	4 41 27.23	+ 2 1 27.6	*n*0.268	0.737
28 9 10 55.2	2	20 , 4	+0 2.74	+7 17.3	4 41 32.95	− 0 37 25.8	*n*9.630	0.745
Nov. 7 9 26 15.9	3	20 , 4	−0 11.38	−9 53.1	4 38 50.99	− 5 35 8.7	*n*9.606	0.765
30 10 57 31.0	1	25 , 5	+0 40.53	+4 25.8	4 21 46.80	−13 12 13.3	*n*8.991	0.840
Dec. 1 11 7 49.8	4	20 , 4	+0 2.02	−6 58.3	4 21 8.31	−13 24 7.6	*n*8.836	0.812

Mean Places for 1891.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	4 43 53.01	+2.57	+ 2 0 40.4	+16.6	Grant 1172
2	4 41 27.52	+2.69	− 0 44 58.3	+15.2	Bonn VI, −0°769
3	4 38 59.51	+2.86	− 5 25 32.4	+16.8	Schjellerup 1519
4	4 24 3.15	+3.12 +3.11	−13 17 21.0	+11.9 +11.7	Greenwich 10-year Catal. 1880

The observation of Nov. 7 was compared with SDM. −5°,1010, and this star was afterwards compared with *Schjellerup*.

NEW ASTEROID.

A planet of the twelfth magnitude was discovered Nov. 27, by **Borrelly** at Marseilles, in the position,

1891 Nov. 27.3808 Greenw. M.T. $\alpha = 4^h\ 6^m\ 6^s.7$, $\delta = +23°\ 12'\ 58''$. Daily motion, −60ˢ and 7′ southward.

NEW ASTRONOMICAL WORK.

Reinhold Hahn, *Mikrometrische Vermessung des Sternhaufens Σ762 ausgeführt am zwölffüssigen Aequatoreal der Leipziger Sternwarte. Königl. Sächsische Gesellschaft der Wissenschaften*, XVII, no. III. Leipzig, 1891.

This cluster is in close vicinity to the cluster Herschel G.C. 4460, which was measured by Dr. **Bruno Peter** at the Leipzig Observatory in the years 1879 and 1882; and since it might well be regarded as a part of the latter, it was selected by Mr. **Hahn** for investigation.

The instrument employed was the same which had been used by Dr. **Vogel** in his *Observations of Nebulas and Clusters*, some twenty years previously, as also subsequently in those of the cluster χ *Persei*, and by Dr. **Koch** in his measurements of the cluster, Herschel 1712. Mr. **Hahn**'s observations were began in the winter 1885–86, and continued during the following year; this first series comprising thirty-eight nights' work. But the results were not found entirely satisfactory, and the instrument was therefore subjected to examination and repairs of various kinds. Later, in the winter 1888–89, a new series of measurements was undertaken, occupying fifty-three nights. The present memoir depends chiefly upon the later measurements, the earlier ones being employed only so far as they proved accordant with these and appeared fully trustworthy.

The memoir begins with an elaborate investigation of the reticule and the micrometer-screw. This is followed by a description of the mode of observation and of the reductions; and finally the definite results are given, with a discussion of the degree of accuracy attained.

The plan of observations implied a comparison of every star of the cluster with at least two, out of nine, principal stars, selected for the purpose at such declinations that, in every case one of the comparisons in declination should be with a more northerly, and one with a more southerly, star. This plan was carried out for sixty-one stars, except that, in a single case, only one of the three comparisous was with a so-called principal star. The resultant catalogue thus contains the respective differences, in R.A. and Decl., of sixty stars, referred to the central one, Lal. 12819 = Σ762, the position of which (equin. 1885.0) is $6^h\ 34^m\ 50^s.87$, $+9°\ 34'\ 18''.5$, and which seems to have no recognizable proper motion.

For the average mean errors of the resultant differences from this central star Mr. **Hahn** finds

±0ˢ.037	and ±0.41	for stars brighter than		11ᴹ.0
±0.063	±0.72	"	fainter	" 11.0

A chart of the cluster is appended to the memoir.

CONTENTS.

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ON THE PERIODIC VARIATION OF LATITUDE, AND THE OBSERVATIONS WITH THE WASHINGTON PRIME-VERTICAL TRANSIT.

BY S. NEWCOMB.

Mr. CHANDLER's remarkable discovery, that the apparent variations in terrestrial latitudes may be accounted for by supposing a revolution of the axis of rotation of the earth around that of figure, in a period of 427 days, is in such disaccord with the received theory of the earth's rotation that, at first, I was disposed to doubt its possibility. But I am now able to point out a *vera causa* which affords a complete explanation of this period.

Up to the present time the treatment of this subject has been this: the ratio of the moment of inertia of the earth around its principal axis to the mean of the other two principal moments, admits of very accurate determination from the amount of precession and nutation. This ratio involves what we might call, in a general way, the solid ellipticity of the earth, or the ellipticity of a homogeneous spheroid having the same moments of inertia as the earth.

When the differential equations of the earth's rotation are integrated, there appear two arbitrary constants, representing the position at any assigned epoch of the axis of rotation relative to that of figure. Theory then shows that the axis of rotation will revolve round that of figure, in a period of 306 days, and in a direction from west toward east. The attempts to determine the value of these constants have seemed to show that both are zero, or that the axes of rotation and figure are coincident. Several years since, Sir WILLIAM THOMSON published the result of a brief computation from the Washington Prime-Vertical observations of *α Lyrae*, which I made at his request, and which showed a coefficient of 0″.05. This coefficient did not exceed the possible error of the result; I therefore regarded it as unreal.

The question now arises whether Mr. CHANDLER's result can be reconciled with dynamic theory. I answer that it can, because the theory which assigns 306 days as the time of revolution is based on the hypothesis that the earth is an absolutely rigid body. But, as a matter of fact, the fluidity of the ocean plays an important part in the phenomenon, as does also the elasticity of the earth. The combined effect of this fluidity and elasticity is that if the axis of rotation is displaced by a certain amount, the axis of figure will, by the changed action of the centrifugal force, be moved toward coincidence with the new axis of rotation. The result is, that the motion of the latter will be diminished in a corresponding ratio, and thus the time of revolution will be lengthened. An exact computation of the effect is not possible, without a knowledge of the earth's modulus of elasticity. But I think the result of investigation will be that the rigidity derived from Mr. CHANDLER's period is as great as that claimed by Sir WILLIAM THOMSON from the phenomena of the tides.

The Washington observations of *α Lyrae*, made during the years 1862–67, are of such importance in their bearing on this subject that I must call attention to the results of their discussion. Their importance arises from the fact that they extend in a nearly unbroken series through a longer period than any other series which had, at that time, been made with an instrument of like precision. They were continued through a term of five years, because, in that way, the ten months inequality in latitude could be determined independently of the constant of aberration, and of all annually recurring anomalies.

An examination of them shows two classes of anomalies: the one of annual period indicated by the negative parallax derived from the observations; the other, systematic deviations from the general mean, which may be explained by periodic variations of the latitude.

To determine the law of the annual anomaly leading to a negative parallax, I take the mean results by months. Every observation being reduced to the epoch 1865, with Boss's proper motion, the mean monthly results are as follows:

Monthly Mean Corrections to the Computed Declinations of α Lyrae, as determined with the Washington Prime-Vertical Transit.

Jan.	+0.13	July	+0.21
Feb.	0.28	Aug.	0.11
Mar.	0.11	Sept.	0.10
Apr.	0.11	Oct.	0.15
May	0.18	Nov.	0.23
June	+0.25	Dec.	+0.[illegible]

The changes thus shown can be immediately interpreted, when we recall that the transit of the star occurs at midnight on June 28, and at noon on Dec. 28. Observations made from April to September inclusive are therefore made with the sun below the horizon, those from October to March with the sun above the horizon. The effect of parallax is clearly shown by the fact that the midnight observations give a larger declination than those made in April and October. But, instead of this law of change continuing through the day, we find that the apparent declination increases rapidly through the day, reaching a maximum about noon.

There is an obvious explanation of this. The day observations are necessarily made during clear weather, when the sun is shining. The slits above the instrument were closed by shutters, against the vertical side of which the sun always shone. On the south slit the sun shone on the outside of the shutter, and therefore no effect would be likely. But when observations were made through the north slit, the line of sight passed within a foot of the heated surface of the shutter. The result would be a refraction of the ray of light, such as to throw the apparent direction of the star towards the north, and thus to increase its declination.

The complete discussion of the observations requires that this effect be taken account of. I have therefore introduced the following unknown quantities into the equations of condition given by the declinations: x, y, constants expressing the coefficients of the supposed ten-month variation of the latitude; b, the correction to **Struve**'s aberration; Δ, the correction to the declination of the star; d, a hypothetical constant coefficient of the cosine of the sun's azimuth, when above the horizon, assumed to be proportional to the heating effect of the sun's rays on the shutter; p', the parallax of *α Lyrae*. The results are:

$$
\begin{aligned}
x &= +0''.025\\
y &= +0.006\\
b &= 0.000\\
p' &= +0.131\\
d &= +0.41
\end{aligned}
$$

This work was done before any suspicion was entertained that the period of latitude could differ from 306 days. It will be seen that on this supposition the variation is so nearly nil that it need not be taken into account. I was, therefore, much surprised when Mr. **Chandler** cited the observations as tending to confirm his new period of 427 days. As he took no account of the annual anomalies, it seemed desirable as soon as possible to test his period by the outstanding residuals after the annual anomalies were eliminated. I therefore divided his period into six parts, the mean of which are shown by the dates in the following table, and took a rough mean of the final residuals for each division. The results are as follows:

					Δ
1862 Apr. 30	1863 July 3	1864 Sept. 5	1865 Nov. 7	1867 Jan. 8	+0″.07
July 10	Sept. 13	Nov. 16	1866 Jan. 17	Mar. 18	+0.11
Sept. 20	Nov. 24	1865 Jan. 26	Mar. 28		+0.05
Dec. 1	1864 Feb. 4	Apr. 7	June 8		—0.09
1863 Feb. 12	Apr. 15	June 17	Aug. 18		+0.02
Apr. 23	June 25	Aug. 27	Oct. 28		—0.20

These appear to be in satisfactory agreement with Mr. **Chandler**'s conclusions, but the coefficient will come out only about 0″.11, or less than half of that which he assigns. The epoch may be expressed by saying that, assuming Mr. **Chandler**'s period, the axis of rotation in its revolution passed the meridians of Washington and Pulkowa about the following dates, which are necessarily uncertain by a month.

Washington	Pulkowa
1865 July	1865 Nov.
1866 Sept.	1867 Jan.
1867 Nov.	1868 Mar.
1869 Jan.	1869 May

The Pulkowa dates are about two months earlier than those found by Mr. **Chandler**.

It is my intention to repeat the solution of the equations of condition, using Mr. **Chandler**'s period, at the earliest possible date. Until this is done no definite conclusion can be drawn.

ANCIENT CHRONOLOGY AND ECLIPSES.

(Letter from W. T. Lynn, Esq., to the Editor.)

I need ask space for only a very few words in reference to Mr. **Stockwell**'s objections to my remarks in No. 246 of this Journal. He puts aside the testimony of **Suetonius**, it is opposed to his views, so that to bring forward nce would be useless. But I must just allude to the one new point in his last letter, by which he endeavors to support his contention that the accepted chronology of Roman history is one year in error. This is founded on the statement of **Plutarch** that, on the night before the assassination of **Julius Caesar**, his wife **Calpurnia** was disturbed

by a dream, and that he saw her by the light of the moon. Now, as the moon was full on the 15th (the Ides) of March in B.C. 45, but was past her third quarter on that day in B.C. 41, Mr. STOCKWELL argues that the former, rather than the latter, was the year of the dictator's murder. It seems to me that he is here led wrong by the expression of SEYFFARTH, (*Summary*, p. 234) "CALPURNIA is awaked by the full light of the moon." This is *not* taken from PLUTARCH, who says that CAESAR looked upon her τῷ φωτὶ καταλαμπούσης τῆς σελήνης, but doubtless from JULIUS OBSEQUENS, the only other extant author, who refers to the moonlight on that occasion, and says that the doors of the chamber opened of their own accord, "*ita ut lunae fulgore qui introvenerat, Calpurnia excitaretur.*" Neither of the ancient authors speaks of the moon as having been full. Now she was full * in B.C. 44 on March 19; CAESAR was assassinated on the day following the night of March 14, when the waning moon, five days before conjunction, would give a good deal of light in the early morning in an open room.

Although Mr. STOCKWELL is misled here, as I think, by SEYFFARTH's language, I notice that he is very far from accepting that writer's system of chronology. SEYFFARTH tries to alter the received date of CAESAR's death by two years, placing it in the year which he calls 41, really corresponding to what is generally called B.C. 42, two days after an eclipse of the moon, (which was not total, as he supposes).

I must refer Mr. STOCKWELL to CLINTON's *Fasti Hellenici* for a proof that JOSEPHUS was probably one year in error, in placing the capture of Jerusalem by HEROD and SOSIUS in B.C. 37: it probably took place in December, B.C. 38, and HEROD's actual reign began in B.C. 37. It will hardly be contended that the Jewish historian, who assigns a duration of eighty years to the reign of SOLOMON, is free from error.

I would just remark, as this is probably the last time I shall trouble you on the subject, that your printer (possibly by a slip of my own) has made me spell CATILINE erroneously in my last letter.

P. S. — In my anxiety to be brief, and save your valuable space, I forgot to refer to Mr. STOCKWELL's argument for his views respecting the correspondence of the Olympic festivals with bissextile years, derived from the date of the death of DARIUS CODOMANNUS. It is remarkable how the true conclusion is the very reverse of that which he draws. The date of the battle of Arbela, or rather of Gaugamela, is of course indubitably fixed by the total eclipse of the moon which occurred shortly (PLUTARCH says eleven days) before the battle. That eclipse, there is no room for dispute, was the one which took place on the evening of Sept. 20, B.C. 331. The murder of DARIUS by BESSUS occurred in the summer of the following year. ARRIAN states positively (lib. iii, c. 7) that it was in the Attic month *Hekatombaion*, the very month, I need not remark, in which the Olympic festivals were celebrated. That, then, being the third year of the 112th Olympiad, and being, as we have seen, B.C. 330, it follows that the first year of that Olympiad, in which the festival was observed, was B.C. 332, whilst the year before this, B.C. 333, would correspond to a bissextile of the Julian Calendar.

W. T. L.

Blackheath, London, Eng., 1891 *Nov.* 24.

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* Doubtless a slip of the pen for "new." — G.

ON THE VARIATION OF LATITUDE,

BY S. C. CHANDLER.

IV.

BRADLEY made no provision at Wanstead, such as he afterwards arranged when the instrument was carried to Greenwich in 1750, for reversal of the sector, whereby the error of collimation could be found and eliminated. This might at first be thought to be a defect in his plan, but, maturely considered, it is rather additional testimony to his wonderful sagacity, although it somewhat increases our difficulties in the present problem. For his purpose the operation of reversal would have been open to grave objection, while its end could be attained in another way, namely, by the combination of stars in opposite right-ascensions, which would eliminate the error of collimation from the aberration and nutation-constants he was seeking to determine. The instrument was therefore used, throughout the whole interval of twenty years, in a fixed position. First, it should be noted that any influence of change in the brickwork mounting, upon the observations, is absolutely out of possible question. Again, it needs but a superficial examination to show that no gradual alteration of the relation of the collimation-axis to the plumb-line occurred during the whole of this long period, which could at most exceed a moderate fraction of a second of arc. BUSCH proved this, and the present reduction fully confirms it, as the following table shows. It is formed by taking, for the separate periods indicated in the headings, the means of the residuals on pp. 77, 78, for the six stars observed during the whole interval, giving half-weight to those resting on but one or two observations.

Decl.	1727-28		1729-30		1731-35		1736-40		1741-47	
° ′	″		″				″		″	
56 20	−0.11	9	−0.25	7½	−0.15	6½	+0.31	4½	+1.05	2½
55 3	−0.07	12	−0.23	8	−0.06	2½	+0.76	1	+0.83	½
52 30	−0.16	11	−0.33	13	+0.38	9½	−0.12	7½	+0.83	4½
51 32	−0.09	11	−0.39	14½	+0.09	11½	−0.57	11	+0.23	6
51 32	−0.07	6	−0.10	3	−0.17	½	−0.11	1½	+1.91	½
50 40	+0.07	9	−0.11	7	+0.26	7½	−0.31	7	+0.34	1½
Means,	−0.08		−0.28		+0.14		−0.23		+0.62	

Only in the last group, 1741–47, is there any sign of decided change in collimation. For this group all the stars give positive values; the earlier groups, in general, negative ones. It is not certain even that these small differences are due to this error, and that they may not be more properly attributed to the falling of the disconnected groups of observations in the later years on different phases of the latitude-change. It is necessary to state here that up to the beginning of 1731, the observations were pretty continuous. But at this point Bradley apparently reasoned that, having obtained enough material to fix the aberration-constant with precision, it was only required, for the nutation, to obtain further observations during a limited period in each year: and after this he made semi-annual journeys from Oxford to Wanstead for this purpose, generally about February and September, until the nutation-period was completed. For our present inquiry this discontinuity operates very disadvantageously, of course; and decisive results can only be obtained from that part of the series between 1727 and 1731.

The possible existence of periodic changes of collimation due to temperature, and dependent on the season of the year, can be disposed of in another way, and it seems to me very convincingly. The only reason for recourse to such hypothetical changes, heretofore, springs from the fact that, notwithstanding the extraordinary exactitude of Bradley's sector-observations — an exactitude which, even with all the advance since his time in optical and mechanical improvements of instrumental construction, and in methods, could scarcely be equaled at the present day — the aberration-constant deduced from them is undeniably erroneous by a quarter of a second. The illustrious Peters sought to account for this puzzling discordance, in his *Recherches sur la Parallaxe des Étoiles Fixes*, by supposing that there was a variability, due to temperature, between the vertical line, indicated by the coincidence of the plumb-line with two fixed points of the instrument, and the optical axis of the telescope. He states that "this is the most probable, and the only possible explanation" of Bradley's erroneous aberration. The opinion of so high an authority ought to be conclusive, and appears to have been generally so regarded; yet I venture with the utmost diffidence to suggest some considerations which seem to set it aside. The annual disturbance which could thus arise is much more important than the diurnal. This, however, would act oppositely on the aberration of stars in opposite right-ascensions; and from Bradley's judicious selection of stars, which was probably governed by this very consideration, it would be almost completely eliminated from his results. But there are two other objections, both more forcible than this, and either of them fatal. First, such an explanation would require the maximum or minimum effects to be exhibited either in midwinter or midsummer. Now the actual phenomenon which I do find, to be presently given, has its maximum and minimum in autumn and spring, respectively, and its mean values in summer and winter. Secondly, if we are to ascribe the phenomenon to instrumental change of any sort, we are landed in a worse dilemma than that from which we seek to escape; for then the argument must be that Bradley's observations, which are equally competent, at least, with any modern series to reveal the change of latitude, do not show it at all, and that therefore the motion of the pole, — which I assume to be conceded from the evidence already adduced, not to mention all that I have yet on hand, unprinted — has originated since Bradley's time, a view so inherently improbable that no one would care to maintain it.

I have thus dwelt upon the proper interpretation of Bradley's work because an exceedingly important and interesting conclusion flows from it: namely, that the period of polar revolution, which, as I have attempted to show, is about 427 days in our own time, was certainly shorter in Bradley's, probably in the neighborhood of a year. A result so curious, if we found no further support, might lead us to distrust the above reasoning, and throw us back to the possibility that, after all, Bradley's observations may have been vitiated by some kind of annual instrumental error. But it will abundantly appear, when I have had opportunity to print the deductions from all the other series of observations down to the present time, that the inference of an increase in the period of polar revolution is firmly established by their concurrent testimony. Before going on, a significant feature of the above table must be noted, which will direct the treatment of the data. In at least three of the periods of time into which the whole series is divided, there is a tendency to system in the mean residuals, which hints at some slight instrumental change dependent on the zenith-distance. Without discussing its nature, which can be more intelligently done in the definitive investigation, it seems

safer to respect this slight symptom of possible error by employing for the present only the six zenithal stars. This should be done at any rate, perhaps, to avoid any appreciable refraction, and other errors mentioned on pp. 79, 80. It is also obviously impracticable to use the discontinuous observations after 1731 until we have some approximate knowledge of the period, at this time. Combining, therefore, the residuals on pp. 77, 78, up to March 1731, of the stars within a degree of the zenith, in 20-day groups, and assuming that the mean values correspond to the middle date of each group, we have the following table:

	″			″	
1727 Sept. 15	+0.42	20	1729 Jan. 27	—0.37	13
Oct. 5	+ .29	17	Feb. 16	— .42	17
Oct. 25	+ .34	14	Mar. 8	—0.77	14
Nov. 14	+ .42	6	Mar. 28	—1.05	9
Dec. 4	+ .36	8	May 7	—0.79	5
Dec. 24	+ .38	8	June 16	— .10	14
1728 Jan. 13	+ .33	19	July 6	— .21	9
Feb. 2	+ .07	9	July 26	+ .30	6
Feb. 22	+ .51	17	Aug. 15	+ .02	18
Mar. 13	+ .76	4	Sept. 4	+ .22	20
Apr. 2	— .68	11	Sept. 24	+ .41	10
Apr. 22	— .98	6	Oct. 14	— .01	5
May 12	— .25	5	Nov. 3	+ .21	10
June 1	— .49	5	Nov. 23	+ .28	5
June 21	— .16	6	Dec. 13	— .36	13
July 11	— .49	22	1730 Feb. 11	+ .12	2
July 31	+ .34	4	Mar. 23	— .77	6
Aug. 20	+ .41	28	June 11	— .63	4
Sept. 9	+ .10	13	Aug. 30	+ .61	18
Sept. 29	+ .18	17	Sept. 19	+ .27	13
Oct. 19	+ .74	5	Dec 28	— .09	10
Nov. 8	+ .02	8	1731 Jan. 17	+ .08	8
Nov. 28	— .39	11	Feb. 26	+0.02	4
1728 Dec. 18	—0.25	20			

The presence of a periodic term in this series with a range of about 1″.0 and a period of about a year, is unmistakeable. It is no mere accidental collocation of signs, for it appears quite as distinctly in the individual stars. It is not an effect of stellar parallax, for the maxima and minima fall at the same places for stars of different right-ascensions. If a chart be formed from the residuals, and a fair curve be drawn, it will be seen that the maxima and minima occur in autumn and spring, the mean values in winter and summer. This fact and the other arguments, above adduced, seem to be cogent against the hypothesis of instrumental effect of temperature. There remains, then, the only natural conclusion of an actual displacement of the zenith, in other words, a change of latitude.

As to the length of the period, from the most careful examination that can at present be made of the data above available, between 1727 and 1731, the only certain inference we can draw from them alone, is that the period for this epoch lies between 350 and 380 days. Normal epochs of maxima and minima can be assigned, however, with considerable sharpness, notwithstanding this slight indeterminateness of the period. By processes which it is unnecessary to describe I find,

Normal epoch of maximum, 1729 Oct. 13
Normal epoch of minimum, 1729 Apr. 27

These values are probably within a very few days of the truth. Attempts to utilize the data between 1731 and 1747 must be deferred for the present, on account of the discontinuity previously alluded to.

The observations at Kew, in 1726 and 1727, with the first zenith-tube, have an intrinsic precision at least equal, and probably superior, to those at Wanstead, but they are much fewer in number. While there are some scattered measures of other stars, only those of *γ Draconis*, 64 in number, are of service. These are invaluable, however, and show the variation of latitude quite as distinctly, notwithstanding their limited extent, as the later series at Wanstead. Applying the same reductions for aberration, nutation and proper motion as before, we get the following differences (O—C), from the mean instrumental polar distance, C = 38° 27′ 55″.46.

		″			
1726 Jan. 7	2	+0.20	1726 Sept. 2	6	+0.31
Mar. 6	2	— .28	Sept 22	8	+ .31
Apr. 12	3	+ .15	Oct. 12	5	+ .72
May 4	3	+ .24	1727 Feb. 2	2	— .19
June 11	6	— .11	June 17	4	+ .35
June 24	7	— .03	Aug. 9	3	— .13
July 11	7	— .33	Sept. 8	2	+0.15
July 23	4	—0.07			

These indicate a maximum about 1726 Oct. 15, and a minimum, less certainly, about 1726 Apr. 18. Either of these times may easily be a month in error. The intervals between these and the above normal dates at Wanstead apparently give a period of 367 days.

So far, then, as the results of this incomparable series of observations at Kew and Wanstead, considered by themselves alone, can now be stated, the period of the polar rotation at that epoch appears to have been probably somewhat over a year, and certainly shorter by about two months than it is at the present time. The range of the variation was apparently in the neighborhood of a second of arc, or considerably larger than that shown by the best modern observations.

Before taking leave of these observations for the present I cannot forbear to speak of the profound impression which a study of them leaves upon the mind, and the satisfaction which all astronomers must feel in recognizing that, besides its first fruits of the phenomena of aberration and nutation, we now owe also our first knowledge of the polar motion to this same immortal work of BRADLEY. Its excellence, highly appreciated as it has been, has still been hitherto obscured by the presence of this unsuspected phenomenon. When divested of its effects, the wonderful accuracy of this work must appear in a finer light, and our admiration be raised to a higher pitch. Going back to it after one hundred and

next years seems, indeed, like advancing into an era of practical astronomy more refined than that from which we pass. And this leads to a suggestion worthy of serious practical consideration, — whether we can do better in the future study of the polar rotation, than again to avail ourselves of BRADLEY'S method, without endangering its elegant simplicity and effectiveness by attempts at improvement, other than supplying certain means of instrumental control which would without doubt commend themselves to his sagacious mind.

In the next article BRADLEY'S later observations at Greenwich, the results of which are not so distinct, will be discussed; and also those of BRINKLEY at Dublin, 1808–13 and 1818–22. This will bring again to the surface one of the most interesting episodes in astronomical history, the spirited and almost acrimonious dispute between BRINKLEY and POND with regard to stellar parallaxes. I hope to show that the hitherto unsolved enigma of BRINKLEY'S singular results finds its easy solution in the fact of the polar motion. The period for his epoch appears to have been about a year, and its range more than a second. Afterwards will follow various discussions, already more or less advanced towards completion. These include BESSEL'S observations at Königsberg, 1820–24, with the REICHENBACH circle, and in 1842–44 with the REPSOLD circle; the latitudes derived from the polar-point determinations of STRUVE and MADLER with the the DORPAT circle, 1822–38; STRUVE'S observations for the determination of the aberration; PETERS'S observations of *Polaris*, 1841–43, with the vertical-circle; the results obtained from the reflex zenith-tube at Greenwich, 1837–1875, whose singular anomalies can be referred in large part to our present phenomenon, complicated with instrumental error, to which they have until now been exclusively attributed; the Greenwich transit-circle results, 1851–65, in which case, however, a similar complication and the large accidental errors of observation seem to frustrate efforts to get any pertinent results; the Berlin prime-vertical observations of WEYER and BRUNNOW, 1845–46, in which I hope to show that the parallax of β *Draconis* derived from them is simply a record of the change of latitude; the conflicting latitude determinations at Cambridge, England; the Washington observations of *Polaris* and other close polars, 1866–87, with the transit-circle; also those at Melbourne, 1863–84, a portion of which have already been drawn upon in the last number of the *Journal*; and some others. While the list is a considerable one, I shall be able to compress the statement of results for many of the series into a short space.

In connection with this synopsis of the scope of the investigations, one or two particulars may be of interest, which at the present writing seem to foreshadow the probable outcome. I beg, however, that the statement will be regarded merely as a provisional one. First, while the period is manifestly subject to change, as has already once or twice been intimated, I have hitherto failed in tracing the variations to any regular law, expressible in a numerical formula. Indeed, the general impression produced by a study of these changes in the length of the period, is that the cause which produces them operates capriciously to a certain degree, although the average effect for a century has been to diminish the velocity of the revolution of the pole. How far this impression is due to the uncertainty of the observations, and to the complication of the phenomenon with other periodical changes of a purely instrumental kind, I cannot say. Almost all of the series of any extent which have been examined, have the peculiarity that they manifest the periodicity quite uniformly and distinctly for a number of years, then for a while, obscurely. In some cases, however, what at first appears to be an objective irregularity proves not to be so by comparison with overlapping series at other observatories.

Another characteristic which has struck my attention, although somewhat vaguely, is that the variations in the length of the period seem to go hand in hand with simultaneous alterations in the amplitude of the rotation; the shorter periods being apparently associated with the larger coefficients for the latter. The verification of these surmises awaits a closer comparative scrutiny, the opportunity for which will come when the computations are in a more forward state. If confirmed these relations will afford a valuable touchstone, in seeking for the cause of a phenomenon which now seems to be at variance with the accepted laws of terrestrial rotation.

OBSERVATIONS OF VARIABLE STARS IN 1891.

BY PAUL S. YENDELL.

112 *R Andromedae.*

R Andromedae has been observed from October 1 to December 16; the observations numbering in all 18. When first seen it was near the limit of visibility, and its light was estimated at $< 11^{M}.0$; it rose steadily to a maximum of $7^{M}.2$, quite sharply marked, on December 2. Its decline has since been rapid, it having fallen a full magnitude when last observed.

4511 *T Ursae Majoris.*

This star has been observed fourteen times, from Sept. 20 to Nov. 20; a maximum of $7^{M}.5$ was passed Oct. 29.

5190 *R Camelopardalis.*

I have observed this variable twenty-three times between Sept. 2 and Dec. 2. A maximum of $7^{M}.7$ is indicated by the observations to have occurred Oct. 22. When last observed its magnitude, by careful estimation, was $9^{M}.0$.

X Herculis.

This star has been observed twenty-three times this season, from March 29 to Oct. 2. A minimum is indicated on May 31, and a rather bright maximum on July 31.

6404 *Y Ophiuchi.*

This star, which is one of SAWYER's recent discoveries, has been observed thirty-nine times. By these observations the following times of maxima and minima are indicated.

MAXIMA	W	MINIMA	W
1891 June 13.8	3	July 10.8	4
July 18.6	3	25.7	4
Aug. 2.9	4	Aug. 9.2	2
Sept. 5.7	3		

6512 *T Herculis*

This star was observed nine times from Aug. 13 to Sept. 23; these observations indicate a maximum on Sept. 4.

6733 *R Scuti.*

This irregular variable has been kept under observation from May 27 to Nov. 4. When first observed it was near a bright maximum, its light being estimated at $4^{M}.6$; it declined to a minimum of $7^{M}.5$ Aug. 19, after which it again rose to a bright maximum of $4^{M}.2$ Sept. 29.5. When last observed it was about $6^{M}.4$.

6849 *R Aquilae.*

R Aquilae was observed from Aug. 6 to Nov. 30, when it was too low in the west for reliable observation. The observations number 26, and show a pretty definite maximum to have been passed Sept. 30, at which time its magnitude was by eye estimation $6^{M}.2$.

6984 *U Aquilae.*

This star was observed thirty-two times, from July 5 to Oct. 21. From these observations have been deduced by SAWYER's mean light-curve, five maxima, and by the single curves, four maxima and four minima. The indicated times are as follows:

MAXIMA	W		MINIMA	W
1891 July 4.86	2	(mean light-curve)	1891 July 9.3	4
12.3	4		31.4	3
27.2	3		Sept. 3.6	4
Aug. 8.84	3	(mean light-curve)	Oct. 1.3	4
24.9	2	“ “ “		
Sept. 8.0	3			
21.25	3			
Oct. 7.16	4	(mean light-curve)		
20.13	1	“ “ “		

7212 *S Aquilae.*

I have made fifteen observations of *S Aquilae*, from Sept. 4 to Dec. 3. A minimum of $11^{M}.0$ is shown on Oct. 3, since which time the star had increased fully a magnitude when last observed.

7257 *R Sagittae.*

This star was, when first observed, apparently near a principal maximum, it being at the time, Aug. 21, estimated at about 8^{M}; a decline to a minimum of $< 10^{M}$ followed, and occurred Sept. 19. A fainter maximum of about $8^{M}.5$ occurred Oct. 2, and a minimum of about $10^{M}.3$ Nov. 10. When last observed, Dec. 3, the star had increased to $8^{M}.8 \pm$; the observations number twenty-five in all.

7299 *U Cygni.*

U Cygni has been observed eighteen times from Aug. 10 to Dec. 3; a maximum is indicated Sept. 6. The strong red color of the star renders estimates of magnitude very difficult and uncertain, and none have been attempted.

7431 *S Delphini.*

S Delphini has been watched since its first appearance in my telescope, on Aug. 22, when I estimated its light at $11^{M}.0 \pm$; it passed its maximum of $8^{M}.5 \pm$ Nov. 23; it is now getting too low in the west for useful observation.

7456 *RR Cygni.*

The observations of *RR Cygni*, whose results have been published in the current volume of this Journal, p. 47, have been continued up to this date. After the phases there detailed, the star declined to about $9^{M}.5$ by Oct. 8, near which magnitude it has since remained, its fluctuations being slight. At the last observation it was estimated to be $9^{M}.7$. It is still under observation.

I take this opportunity to make public acknowledgment of the great assistance to my work on the Variable Stars, rendered by the National Academy of Sciences, in the form of a grant from the Bache Fund of a sum of money sufficient to build a small observatory, and mount my telescope in a manner suitable for my work, and my hearty thanks are due to the Board of Direction for this substantial and valuable help, which practically doubles my working power.

On account of the vexatious delays which seem to be inseparable from any such undertaking, the work is not yet entirely finished; but the observatory and instrument are in shape to do all that is to be done with the means at hand.

An observatory has been built, consisting of a small two-story frame building, surmounted by a conical revolving dome, under the center of which is a brick pier which supports the telescope, mounted on a substantial equatorial stand, with finding circles. Various eyepieces and accessories have also been added to this instrument, to meet the needs of the work for which it is intended.

Although not at the time finished, observations were begun in the building 1891 April 2, and have since been car-

ried on continuously. Nearly two thousand observations have been made, on known and suspected variable stars numbering rather more than a hundred and twenty; and more than a hundred daily counts of sun-spots have been secured. It is intended to keep up the same lines of work in the future, paying especial attention to new and suspected variables, and the minima of such telescopic stars as come within the grasp of my instrument.

Dorchester, Mass., 1891 *December* 18.

OBSERVATION OF THE PERIODIC COMET OF WOLF (*b* 1891),

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 9.6-INCH EQUATORIAL,

By Prof. E. FRISBY.

[Communicated by the Superintendent.]

1891 Washington M.T.	✳	No. Comp.	☄ — ✳		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
Dec. $5^d\ 10^h\ 10^m\ 16^s.8$	1	20 , 4	$+4^m\ 53^s.37$	$+7'\ 2''.3$	$4^h\ 21^m\ 45^s.06$	$-14^\circ\ 1'\ 14''.0$	$n9.122$	0.842

Mean Place for 1889.0 of Comparison-Star.

✳	α	Red. to app. place	δ	Red. to app. place	Authority
1	$4^h\ 16^m\ 48^s.51$	$+3^s.18$	$-14^\circ\ 8'\ 27''.5$	$+11''.2$	Lalande 8240

The Lalande position was reduced directly, and the star afterwards compared with Weisse 346 and 351, whence other positions were deduced; the results are,

α 1891.0 = $4^h\ 16^m\ 48^s.45$	δ 1891.0 = $-14^\circ\ 8'\ 22''.7$
48.46	29.0
48.59	28.3

The first position, being a direct comparison with Lalande, has been given ½ weight.

EPHEMERIS OF *S ANTLIAE.*

Observations of this variable are now highly desirable. The ephemeris given in *A.J.* 228 (vol. X, p. 94) is applicable for the present season, provided it be borne in mind that the Greenwich times, given in the last column of the table, will correspond during the present season until 1892 Feb. 28, to dates twenty-four days earlier than those of the table. From Feb. 29 on, the times will correspond to dates twenty-three days earlier.

TRANSIT OF *MERCURY*, 1891 MAY 3.

Professor Schur, of Göttingen, requests the early publication of any yet unpublished observations of this transit, which may have been made in America.

CONTENTS.

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ON THE COMPUTATION OF PLACES IN ECCENTRIC ELLIPSES AND HYPERBOLAS,

BY REV. G. M. SEARLE.

The following formulas for computing places and times in eccentric orbits have the advantage of not requiring, except in unusual cases, any tables except Barker's and the ordinary trigonometrical ones, and would seem to have all the accuracy and convenience that can be desired.

The equation $M = E - e\sin E$ can of course be written

either as $M = (1-e)\sin E + (E - \sin E)$

or as $M = (1-e)E + e(E - \sin E)$.

Also, if we multiply the first by any quantity whatever, m, and the second by $1-m$, and add the results, we have

$$M = (1-e)\,[m\sin E + (1-m)\,E] + [m + (1-m)e]\,(E - \sin E)$$

or denoting, $m\sin E + (1-m)\,E$ by x

and $m + (1-m)\,e$ by e_0

$$M = (1-e)\,x + e_0(E - \sin E)$$

Now we have $x = E - \frac{mE^3}{6} + \frac{mE^5}{120}$ &c.,

and of course a development can therefore be made, of the form $E = x + ax^3 + bx^5$ &c.

and evidently also, $a = +\frac{m}{6}$

Furthermore

$$E - \sin E = \frac{E^3}{6} - \frac{E^5}{120} \text{ \&c.} = \left(\frac{x^3}{6} + \frac{a}{2}x^5 \text{ \&c.}\right) - \frac{x^5}{120} \text{ \&c.}$$

Now it will be convenient to give m such a value that the coefficient of x^5 in this last development is equal to zero, since by this means the lowest power of x in the equation for M, not reducible to the form of BARKER's table, will be made to disappear. This value is easily obtained, since we have from this condition $a = \frac{1}{60}$; and we already know that $a = \frac{m}{6}$; hence $m = \frac{1}{10}$.

We have then $x = \frac{9}{10}E + \frac{1}{10}\sin E$

This function is the one adopted by GAUSS in his solution of the problem; but it is here used in a somewhat less complicated, and seemingly not less convenient, way.

Adopting the value of m, we find

$$E = x + \tfrac{1}{60}x^3 - \tfrac{1}{28000}x^7 - \tfrac{1}{504000}x^9 + \tfrac{1}{3520000}x^{11} \text{ \&c.}$$

For $E - \sin E$, we have

$$E - \sin E = \frac{1}{m}\,(E - x): \quad \text{hence}$$

$$E - \sin E = \tfrac{1}{6}x^3 - \tfrac{1}{2800}x^7 - \tfrac{1}{50400}x^9 + \tfrac{1}{352000}x^{11} \text{ \&c.}$$

We have then for M:

$$M = (1-e)\,x + e_0\left[\tfrac{1}{6}x^3 - \tfrac{1}{2800}x^7 \text{ \&c.}\right]$$

Now making $\frac{2(1-e)}{e_0} = \varepsilon^2$, this becomes

$$\frac{2M}{e_0\varepsilon^3} = \frac{x}{\varepsilon} + \frac{x^3}{3\varepsilon^3} - \frac{2}{\varepsilon^3}\left[\tfrac{1}{2800}x^7 + \tfrac{1}{50400}x^9 \text{ \&c.}\right]$$

or denoting $\frac{x}{\varepsilon}$ by $\tau (= \tan\tfrac{1}{2}w)$ we have

$$\frac{2M}{e_0\varepsilon^3} = \tau + \tfrac{1}{3}\tau^3 - \frac{\varepsilon^4}{1400}\left[1 + \tfrac{1}{18}x^2 - \tfrac{1}{5500}x^4 \text{ \&c.}\right]\tau^7$$

Now $2M = 2kt\,a^{-\frac{3}{2}}$ and $e_0\varepsilon^3 = \frac{[2(1-e)]^{\frac{3}{2}}}{\sqrt{e_0}}$.

Hence our equation may be written

$$\frac{\sqrt{2}}{k}\,(\tau + \tfrac{1}{3}\tau^3) = t\sqrt{e_0}\,q^{-\frac{3}{2}} + \frac{\sqrt{2}}{1400k}\,\varepsilon^4\left[1 + \tfrac{1}{18}x^2 \text{ \&c.}\right]\tau^7$$

or, if we use the original form of BARKER's table,

$$75(\tau + \tfrac{1}{3}\tau^3) = \frac{75k}{\sqrt{2}}\sqrt{e_0}\,q^{-\frac{3}{2}}\,t + \tfrac{3}{56}\varepsilon^4\left[1 + \tfrac{1}{18}x^2 \text{ \&c.}\right]\tau^7$$

By this equation w can be found and the slight correction for the last term easily applied. This correction will almost always be so small that the quantity $1 + \frac{1}{18}x^2$ &c. may be taken equal to unity.

In fact we have for the correction dw to be applied to the first value of w taken simply from the equation

$$M = e_0\,q^{-\frac{3}{2}}\,t$$

$$dw = \sqrt{2}k\cos^4\tfrac{1}{2}w\,dM = \tfrac{1}{700}\varepsilon^4\left[1 + \tfrac{1}{18}x^2 \text{ \&c.}\right]\tau^7\cos^4\tfrac{1}{2}w$$

or expressing it in seconds of arc

$$dw = 294''.66\,\varepsilon^4\left[1 + \tfrac{1}{18}x^2 \text{ \&c.}\right]\tau^7\cos^4\tfrac{1}{2}w$$

And evidently it will make no difference in dw what particular form of Barker's table has been used.

Now to pass from e to w, or *vice versa*.

We find, by developing according to powers of E,

$$(\cos\tfrac{1}{2}E)^{1/5} = 1 - \tfrac{1}{40}E^2 - \tfrac{7}{9600}E^4 - \tfrac{53}{1152000}E^6 \text{ \&c.}$$

also developing in the same powers

$$\frac{2\sin\frac{1}{2}E}{x} = 1 - \tfrac{1}{40}E^2 - \tfrac{7}{9600}E^4 + \tfrac{41}{1612800}E^6 \text{ \&c.}$$

Hence $$\frac{x\cos^{1/5}\frac{1}{2}E}{2\sin\frac{1}{2}E} = 1 - \tfrac{1}{14000}E^6 \text{ \&c.}$$

or $$x = 2\tan\tfrac{1}{2}E\cos^{4/5}\tfrac{1}{2}E\,(1 - \tfrac{1}{14000}E^6 \text{ \&c.})$$

or, denoting $\sqrt{\dfrac{1+e}{2e_0}}$ by η

$$\tau = \frac{1}{\eta}\tan\tfrac{1}{2}v\cos^{4/5}\tfrac{1}{2}E(1 - \tfrac{1}{14000}E^6 \text{ \&c.})$$

We shall also find

$$\cos^{6/5}\tfrac{1}{2}E = 1 - \tfrac{3}{20}E^2 + \tfrac{1}{200}E^4 - \tfrac{1}{24000}E^6 \text{ \&c.}$$

or putting for E its development in powers of x, given above,

$$\cos^{6/5}\tfrac{1}{2}E = 1 - \tfrac{3}{20}x^2 + \tfrac{1}{4000}x^6 \text{ \&c.}$$

Now denoting $\sqrt{\dfrac{3}{20}}\,x$ by $\sin\xi$

$$\cos^{6/5}\tfrac{1}{2}E = \cos^2\xi(1 + \tfrac{1}{4000}x^6 \text{ \&c.})$$

and hence $$\cos^{4/5}\tfrac{1}{2}E = \cos^{4/3}\xi(1 + \tfrac{1}{6000}x^6 \text{ \&c.})$$

Hence $$\tau = \frac{1}{\eta}\tan\tfrac{1}{2}v\cos^{4/3}\xi(1 + \tfrac{1}{10500}x^6 \text{ \&c.})$$

or $$\tan\tfrac{1}{2}v = \eta\tau\sec^{4/3}\xi(1 - \tfrac{1}{10500}x^6 \text{ \&c.})$$

For r, the radius vector, we have

$$r = q\sec^2\tfrac{1}{2}v\cos^2\tfrac{1}{2}E$$
$$= q\sec^2\tfrac{1}{2}v\cos^{10/3}\xi(1 + \tfrac{1}{2400}x^6 \text{ \&c.})$$

By means of these rather curious formulas, we can pass easily from $\tan\frac{1}{2}v$ to τ, or *vice versa*; and hence easily obtain, with great approximation, the time from the anomaly, or the anomaly and radius vector from the time.

Since $x = \varepsilon\tau$, we have $\sin\xi = \sqrt{\dfrac{3}{20}}\,\varepsilon\tau$

$\sqrt{\dfrac{3}{20}}\,\varepsilon = [9.7385606]\sqrt{\dfrac{1-e}{e_0}}$ may be denoted, for convenience, by f.

$$x \text{ then } = \sqrt{\frac{20}{3}}\,f\tau = \sqrt{\frac{20}{3}}\sin\xi$$

which gives

$$\tan\tfrac{1}{2}v = \eta\,\tau\sec^{4/3}\xi(1 - \tfrac{16}{567}\sin^6\xi \text{ \&c.})$$
$$r = q\sec^2\tfrac{1}{2}v\cos^{10/3}\xi(1 + \tfrac{10}{81}\sin^6\xi \text{ \&c.})$$

The practical formulas for computation are then as follows.

First obtain for the ellipse in question

$$e_0 = \tfrac{9}{10}e + \tfrac{1}{10}$$
$$f = [9.7385606]\sqrt{\frac{1-e}{e_0}}$$
$$\eta = \sqrt{\frac{1+e}{2e_0}}$$
$$\begin{cases} n = k\sqrt{e_0}\,q^{-3/2} & \text{for } M = \dfrac{\sqrt{2}}{k}(\tau + \tfrac{1}{3}\tau^3) \\ n = [9.9601277]\sqrt{e_0}\,q^{-3/2} & \text{for } M = 75(\tau + \tfrac{1}{3}\tau^3) \end{cases}$$
$$e_1 = \tan(45 - \tfrac{1}{2}\varphi) = [0.1109244]\frac{f}{\eta}$$

I. To obtain the time from the anomaly.

First compute, beside the constants already given,

$$g = [0.4166230]\frac{f^4q^{3/2}}{\sqrt{e_0}}$$

Then for each particular place,

$$\tan\tfrac{1}{2}E = e_1\tan\tfrac{1}{2}v$$

$$\tan\tfrac{1}{2}w = \tau = \frac{1}{\eta}\cos^{4/5}\tfrac{1}{2}E\cdot\tan\tfrac{1}{2}v(1 - \tfrac{1}{14000}E^6 \text{ \&c.})$$

For w take out M from Barker's table.

Then $$t = \frac{M}{n} - g(1 + \tfrac{10}{27}f^2\tau^2 \text{ \&c.})\tau^7$$

II. To obtain the anomaly and radius vector from the time.

Compute first, instead of g, $h = [1.1171116]\,f^4$

Then for the particular place,

$$M = nt$$

Take out w corresponding to M from the table.

The correction to w, (always arithmetically additive if w is taken from −180° to +180°.) is

$$dw \text{ (in seconds of arc)} = h\tau^3\sin^4\tfrac{1}{2}w(1 + \tfrac{10}{27}\sin^2\xi \text{ \&c.})$$
$$\sin\xi = f\tau \quad (\tau = \tan\tfrac{1}{2}w,\ w \text{ being the corrected value.})$$
$$\tan\tfrac{1}{2}v = \tau\eta\sec^{4/3}\xi(1 - \tfrac{16}{567}\sin^6\xi \text{ \&c.})$$
$$r = q\sec^2\tfrac{1}{2}v\cos^{10/3}\xi(1 + \tfrac{10}{81}\sin^6\xi \text{ \&c.})$$

The factors in parenthesis will rarely need to be used. Very small tables would suffice for them. In the following example, that of GAUSS, we will neglect them.

For this we have $\log q = 9.7656500$
$e = 0.96764567$

Hence, $\log e_0 = 9.9871660$
$\log f = 8.9999138$
$\log\eta = 0.0028754$
$\log n = 0.3451080$ (1st formula.)

I Time from Place		II Place from Time	
$\log g$	6.0713	$\log h$	0.1169
$v =$	100° 0′ 0″	$t =$	63.54400
$\tan\frac{1}{2}v$	0.0761865	w	99° 6′ 14″.32
$\tan\frac{1}{2}E$	9.1841793	dw	+0″.71
$\cos\frac{1}{2}E$	9.9949871	τ	0.0693007
$\frac{1}{\eta}(\cdot\cdot)^{4/5}$	9.9931143	$ft = \sin\xi$	9.0692445
		$\sec\xi$	0.0030078
τ	0.0693008	$\eta(\cdot\cdot)^{4/3}$	0.0068858
w	99° 6′ 15″.06	$\tan\frac{1}{2}v$	0.0761865
$\frac{M}{n}$	63.54438	$\sec^2\frac{1}{2}v$	0.3838650
corr.	—00036	$(\cos\xi)^{10/3}$	9.9899740
t	63.54402	q	9.7656500
		$\log r$	0.1394890

It will be seen that the effect of the factors in parenthesis is usually insignificant, as in this example. The discrepancy in t is due merely to the unavoidable errors of the seventh place.

For the hyperbola, the formulas are nearly as simple. Beginning with

$$e\tan F - \text{nat log}\tan(45^\circ+\tfrac{1}{2}F) = \frac{kt(e-1)^{3/2}}{q^{3/2}}$$

and treating this in the same way as the equation for the ellipse, we find that the proper value for x is $\frac{1}{10}\tan F + \frac{9}{10}$ nat log $\tan(45^\circ+\frac{1}{2}F)$.

Developing x in powers of F, we have

$$x = F + \tfrac{11}{60}F^3 + \tfrac{61}{1200}F^5 + \tfrac{821}{50400}F^7 + \tfrac{20401}{3628800}F^9 \text{ \&c.}$$

which gives

$$F = x - \tfrac{11}{60}x^3 + \tfrac{1}{20}x^5 - \tfrac{439}{28000}x^7 + \tfrac{6711}{1260000}x^9 \text{ \&c.}$$

and $\tan F -$ nat log $\tan(45^\circ+\frac{1}{2}F)$

$$= \tfrac{1}{6}x^3 - \tfrac{1}{2800}x^7 + \tfrac{1}{50400}x^9 \text{ \&c.}$$

Making then $\qquad e_0 = \frac{9}{10}e + \frac{1}{10} \qquad$ as before

and $\qquad \varepsilon = \sqrt{\dfrac{2(e-1)}{e_0}}$

and $\qquad \tau = \dfrac{x}{\varepsilon}, \quad$ we have

$$\frac{\sqrt{2}}{k}(\tau+\tfrac{1}{3}\tau^3) = \frac{t\sqrt{e_0}}{q^{3/2}} + \frac{\sqrt{2}}{1400k}\varepsilon^4(1-\tfrac{1}{18}x^2 \text{ \&c.})\tau^7$$

We have now to pass from τ to $\tan\frac{1}{2}v$, and *vice versa*, as before.

Developing $\tan\frac{1}{2}F$ in powers of F, we have, dividing by the expression for x above,

$$\frac{2\tan\frac{1}{2}F}{x} = \cos^{4/3}\tfrac{1}{2}F[1-\tfrac{1}{40}F^4 - \tfrac{353}{12000}F^6 \text{ \&c.}]$$

and developing $\tan\frac{1}{2}F$ in powers of x,

$$\frac{2\tan\frac{1}{2}F}{x} = 1 - \tfrac{1}{10}x^2 + \tfrac{1}{80}x^4 - \tfrac{11}{7000}x^6 \text{ \&c.}$$

Now making $\quad \tan\xi = \sqrt{\dfrac{3}{20}}\,x, \quad$ we find

$$\cos^{4/3}\xi = (1+\tfrac{3}{20}x^2)^{-2/3} = 1 - \tfrac{1}{10}x^2 + \tfrac{1}{80}x^4 - \tfrac{1}{600}x^6 \text{ \&c.}$$

Hence $\qquad \dfrac{2\tan\frac{1}{2}F}{x} = \cos^{4/3}\xi[1+\tfrac{1}{10500}x^6 \text{ \&c.}]$

But $\tan\frac{1}{2}v = \sqrt{\dfrac{e+1}{e-1}}\tan\frac{1}{2}F$: hence, making $\eta = \sqrt{\dfrac{1+e}{2e_0}}$ as before

$$\tan\tfrac{1}{2}v = \eta\tau\cos^{4/3}\tfrac{1}{2}F[1-\tfrac{1}{40}F^4 - \tfrac{353}{42000}F^6 \text{\&c.}]$$

$$= \eta\tau\cos^{4/3}\xi[1+\tfrac{1}{10500}x^6 \text{ \&c.}]$$

The first formula, however, is objectionable on account of its involving the fourth power of F. We shall obtain a better one by developing, first, F in terms of $2\tan\frac{1}{2}F$, which we will denote by f, so that $F = 2\tan^{-1}\frac{1}{2}f$; this gives

$$F = f - \tfrac{1}{12}f^3 + \tfrac{1}{80}f^5 - \tfrac{1}{448}f^7 \text{ \&c.}$$

They developing x in powers of f by means of this, we have

$$x = f + \tfrac{1}{10}f^3 + \tfrac{7}{400}f^5 + \tfrac{1}{280}f^7 \text{ \&c.}$$

But $\quad f(1-\frac{1}{4}f^2)^{-2/5} = f + \frac{1}{10}f^3 + \frac{7}{400}f^5 + \frac{7}{2000}f^7$ &c.

whence $\qquad \dfrac{f}{x} = (1-\tfrac{1}{4}f^2)^{2/5}(1-\tfrac{1}{14000}f^6 \text{ \&c.})$

Now if we make $\quad \frac{1}{2}f = \sin\frac{1}{2}F', \quad$ or $\quad \tan\frac{1}{2}F = \sin\frac{1}{2}F'$, this becomes

$$\frac{2\tan\frac{1}{2}F}{x} = \cos^{4/5}\tfrac{1}{2}F_0(1-\tfrac{1}{14000}F_0^6 \text{ \&c.})$$

Hence $\quad \tau = \dfrac{1}{\eta}\tan\tfrac{1}{2}v\sec^{4/5}\tfrac{1}{2}F_0(1+\tfrac{1}{14000}F_0^6 \text{ \&c.})$

in which $\qquad \sin\frac{1}{2}F_0 = \sqrt{\dfrac{e-1}{e+1}}\tan\frac{1}{2}v$

It remains to obtain a formula for the radius vector.

We have $\quad r\cos^2\frac{1}{2}v = \dfrac{q\cos^2\frac{1}{2}F}{\cos F} = q[\tfrac{1}{2}+\tfrac{1}{2}\sec F]$

Now $\quad \sec F = 1 + \frac{1}{2}F^2 + \frac{5}{24}F^4 + \frac{61}{720}F^6$ &c.

Hence $\quad \frac{1}{2}+\frac{1}{2}\sec F = 1 + \frac{1}{4}x^2 + \frac{1}{80}x^4 - \frac{1}{1600}x^6$ &c.

But $\quad \sec^{10/3}\xi = (1+\frac{3}{20}x^2)^{5/3} = 1 + \frac{1}{4}x^2 + \frac{1}{80}x^4 - \frac{1}{4800}x^6$ &c.

Hence $\qquad r\cos^2\frac{1}{2}v = q\sec^{10/3}\xi(1-\frac{1}{2400}x^6$ &c.)

The constants to be prepared for computation are just the same as for the ellipse, except that in f we have $e-1$ instead of $1-e$.

The quantity e_1 is still $[0.1109211]\dfrac{f}{\eta}$

I. To obtain the time from the anomaly,

$$\sin\tfrac{1}{2}F_0 = e_1\tan\tfrac{1}{2}v$$

$$\tan\tfrac{1}{2}w = \tau = \frac{1}{\eta}\tan\tfrac{1}{2}v\sec^{4/5}\tfrac{1}{2}F_0(1+\tfrac{1}{14000}F_0^6 \text{ \&c.})$$

For w take out M from the table.

$$t = \frac{M}{n} - g(1-\tfrac{12}{7}f^2\tau^2)\tau^7$$

II. To obtain the anomaly and radius vector from the time,

$$M = nt$$

Take out w corresponding to M from the table.

The correction to w, additive as before, is

$$dw = h\tau^7\sin^4\tfrac{1}{2}w(1-\tfrac{12}{7}\tan^2\xi \text{ \&c.})$$

$$\tan\xi = f\tau$$

$$\tan\tfrac{1}{2}v = \eta\tau\cos^{4/5}\xi(1+[illegible]\tan^6\xi \text{ \&c.})$$

$$r = q\sec^2\tfrac{1}{2}v\sec^{[illegible]}\xi(1-[illegible]\tan^6\xi \text{ \&c.})$$

The correspondence of these formulas with those for the ellipse is manifest; the principal change is that we have $\tan\xi = f\tau$, instead of $\sin\xi$; and $\sin\frac{1}{2}F_0 = e_1\tan\frac{1}{2}v$ instead of $\tan\frac{1}{2}F_0$.

For the example in this case we will take the second one of GAUSS. For the constants we have,

$\log q = 0.0201657$

$e = 1.2618820$

Hence,

$\log e_0 = 0.0913108$

$\log f = 9.1016580$

$\log \eta = 9.9807645$

$\log n = 0.0157069$

I

Time from Place.

$\log g$	8.0075
$e =$	$67^\circ\ 3'\ 0''.00$
$\tan\frac{1}{2}e$	9.8211916
$\sin\frac{1}{2}F_0$	9.3530125
$\sec\frac{1}{2}F_0$	0.0113251
$\frac{1}{\eta}(\,''\,)^{1/3}$	0.0282958
log factor	3
τ	9.8191907
w	$70^\circ\ 31'\ 46''.18$
$\frac{M}{n}$	65.41326
corr.	—00090
t	65.41236

II

Place from Time.

$\log h$	1.7238
$t =$	65.41236
w	$70^\circ\ 31'\ 44''.08$
dw	$+2''.08$
τ	9.8191907
$ft = \tan\xi$	9.2511487
$\sec\xi$	0.0067957
$\eta(\cos\xi)^{1/3}$	9.9717036
log factor	4
$\tan\frac{1}{2}v$	9.8211917
$(\sec\xi)^{10/3}$	0.0226523
$\sec^2\frac{1}{2}v$	0.1580378
factor	—17
$\log q$	0.0201657
$\log r$	0.2008511

The factors, even for this unusual value of e, differ very little from unity. In case they have to be computed, the easiest way would be to first obtain $[6.5197]\ (\frac{1}{2}E \text{ or } \frac{1}{2}F_0)^6$ or $[7.1852]\ (\sin \text{ or } \tan\xi)^6$; this is the logarithm of

$$1 + \frac{(E \text{ or } F_0)^6}{84000}$$

or of $1 + \frac{2}{567}\xi^6$; and must be multiplied by 6 in the formulas in which E or F, are used, and by 8 and 35 respectively in those in which ξ is used; regard being of course taken of the sign.

The formula $\qquad r = q \sec^2\frac{1}{2}v \sec^2\frac{1}{2}F_0$

may be noted, as convenient for computing r from v in the hyperbola; it is easily obtained from the expression

$$r = q \sec^7\tfrac{1}{2}v \cos^2\tfrac{1}{2}F \sec F$$

ON THE RELATION OF THE PERIODIC AND SECULAR VARIATIONS OF THE LATITUDE.

By GEORGE C. COMSTOCK.

I have published in the *American Journal of Science* for December, 1891, a discussion of the data furnished by observations at Pulkowa, Koenigsberg, Washington and Madison, from which there appears to result a progressive motion of the terrestrial pole whose effect upon the latitudes of these observatories is represented by the expression

$$\varphi = \varphi_0 + 0''.044 \cos(\lambda - 69^\circ)(t - t_0)$$

in which the longitudes, λ, are reckoned from the meridian of Greenwich, and the unit of t is a year. I do not wish at present to advance any hypothesis in regard to the cause of this secular change of latitudes, but rather to treat it as a phenomenon, which, though still requiring confirmation or disproof, has been empirically placed upon such a basis that its existence may be legitimately assumed as a working hypothesis, and its relation to other phenomena discussed from this standpoint.

The first point to which I wish to call attention, is that the existence of a secular term in the latitudes will necessarily produce a periodic term also, for by virtue of its progressive motion the instantaneous axis of rotation of the earth is moved away from that principal axis of inertia which is usually designated by the letter C. The forces developed through the separation of these axes will tend to readjust the figure of the earth so as to bring these axes again into coincidence; but this readjustment can not be instantaneous, and the axis of figure will lag behind the axis of rotation by an amount depending in great part upon the modulus of the earth's rigidity, thus producing the theoretical periodic motion of the pole which is associated with EULER's name.

Professor NEWCOMB has indicated (*A.J.* no. 251) that the imperfect rigidity of the earth may produce a very appreciable lengthening of this period, and he is inclined to attribute to this cause alone the total excess of the period found by Mr. CHANDLER over the value 306 days, which would obtain in a rigid earth. But since we are constrained to regard the rigidity of the earth as practically constant, for short periods of time at least, the supposition of an imperfect rigidity affords no explanation of the anomalous variations in the amplitude and period of the CHANDLER inequality, both of which, however, can be accounted for by combining with this cause a secular change in the position of the pole.

My investigation of the numerical elements which determine the amount and direction of the motion of the pole has been based upon the assumption that this motion can be represented as a linear function of the time, but this assumption is obviously a mere analytical device, which can make no claim to objective reality. In the absence of a theoretical expression for this variation the analogy furnished by the precession and nutation would indicate a form involving both powers and circular functions of the time, and I therefore assume for my present purpose that the spherical coordinates of the movable pole at any instant t may be expressed in the form

$$\xi = a_1\tau + b_1\tau^2 + c\sin(\tau m + C) + \text{etc.}$$
$$\eta = a_2\tau + b_2\tau^2 + c\cos(\tau m + C) + \text{etc.}$$

where the position of the pole at the instant t_0 is assumed as origin, and $\tau = t - t_0$. The effect of the motion, represented by these coordinates, upon the latitude of a place whose longitude is λ will be

$$\varphi - \varphi_0 = \xi\cos\lambda + \eta\sin\lambda,$$

and the complete expression for the variation of the latitude will be obtained by adding to these terms a term represent-

ing the **Euler** inequality. We thus obtain after the proper substitutions are made,

$$\varphi = \varphi_0 + \alpha\tau + \beta\tau^2 + c\sin(\tau m + C + \lambda) + e\sin(\tau n + E + \lambda),$$

in which the significance of the coefficients α and β is obvious.

In so far as its periodic terms are concerned, this equation is of the form discussed by **Helmert** (*Astr. Nachr.* no. 3014), and whose graphical representation for certain assumed values of the constants is there given. An inspection of these curves will show the following peculiarities, which are in striking conformity with the empirical results of Mr. **Chandler**'s investigation given in no. 251 of this Journal:

(*a*). The sum of the terms gives a longer period than would result from the term in e taken alone.

(*b*). The periods are of unequal length, in the particular cases treated ranging from eleven to fifteen months.

(*c*). The amplitude of the variation is different in different periods, and a large value of the coefficient is associated with the shorter periods and small values with the longer ones.

It is further obvious from an inspection of the terms in c and e that, if m and n are not very unequal, there will be considerable intervals of time within which the terms will have opposite signs, and will thus tend to efface the periodic variation.

All of the characteristic features of the periodic term detected by Mr. **Chandler** seem to admit of explanation through an assumed nutation in the secular motion of the pole. To sum the whole matter in a few words: any secular variation in the position of the pole will produce a periodic variation of latitudes. If the secular variation is a uniform motion along a great circle, the periodic term will be of constant amplitude and length, but if the secular variation itself contains periodic terms they will manifest their presence through irregularities in the periodic terms of the latitude.

In the absence of a theoretical cause for the secular variation the considerations here presented cannot serve as an explanation of the periodic inequalities in question, and my purpose in presenting them is primarily to call attention to the close relation which exists between the two classes of variation in the latitude, and to emphasize the probable futility of investigations which are confined to either one. The data which seem to be most needed at the present time must be afforded by a determination, by differential methods, of the secular change in the latitude. An outline of such methods has been suggested both by **Fergola** and by myself in the article above cited, and in view of the probable magnitude of the secular term, observations at properly selected parts of the earth's surface would in a very few years furnish a much better determination of this element than can be derived from all existing data.

Washburn Observatory, 1892 *January*.

ON A NEW VARIABLE IN *VULPECULA*.

$20^{h}\,28^{m}\,23^{s}.7,\quad +27°\,30'.0$ (1855.0).

By PAUL S. YENDELL.

From my observations since June, 1888, the star *F.* 32 *Vulpeculae* (= DM. 27°3911) appears to be a variable of the irregular type.

I was led to suspect this fact from the reduction of my observations of *T Vulpeculae*, for which it has been used as a comparison-star (*A.J.* vol. VII, p. 2), the comparisons for the season of 1888 exhibiting a marked discordance. For this reason, it was practically discarded during the season of 1889, the few observations in which it was used being apparently rather non-committal. In the autumn of 1890 a few observations were made, with a view to the further elucidation of the question; but other more pressing work intervening, the matter was not at that time followed up.

While observing *T Vulpeculae*, 1891 Sept. 23, the faintness of *F.* 32 attracted my attention, and I began a series of comparisons for the purpose of definitely settling the question of the star's variability. A very marked increase in brightness was soon evident, and the star has been followed up to the 19th inst., the last occasion, up to this date, when observation has been possible. The result of these observations appears to place the fact of the star's variability beyond a doubt.

I find this star included in Dr. **Chandler**'s collection of suspected variables, *H.C.O.*, vol. XIV, p. 70, as having been mentioned by **Gilliss** as previously recorded between $4^{\mathrm{M}}.5$ and $5^{\mathrm{M}}.6$.

Its magnitude is given by various authorities, as follows: D.M., $5^{\mathrm{M}}.3$; *Uranometria Nova*, 5·6; **Heis**, 5·6; **Chandler** (*loc. cit.*) $5^{\mathrm{M}}.27$; *Harvard Photometry*, $5^{\mathrm{M}}.11$; *Madras Meridian Observations*, $5^{\mathrm{M}}.1$; **Yarnall**, $4^{\mathrm{M}}.5$; *Glasgow Gen. Catalogue*, $4^{\mathrm{M}}.5$.

The limits of variation observed by me are from $4^{\mathrm{M}}.9$ to $6^{\mathrm{M}}.15$, but I have not been able to reconcile the fluctuations with any regular period, as the star apparently remains at times very nearly constant, at its maximum brightness, for considerable periods, while the changes at other times are marked and abrupt.

The comparison-stars used are some of the same designated by **Chandler** in his paper on *T Vulpeculae*, above quoted. For convenience of comparison, I append the list of those employed, with his magnitude and my own light-scale:

	L.	Mag.
b	9.3	5.7
c	4.8	6.17
f	0.0	6.80

The following table gives the observed light-values by this scale, together with the magnitudes therefrom deduced.

	L.	Mag.		L.	Mag.
1888 June 4.4	11.6	5.40	1889 Feb. 25.7	14.3	5.07
5.4	11.4	5.17	May 26.4	14.3	5.07
9.4	12.3	5.33	Sep. 27.3	13.3	5.19
13.4	15.3	4.95	Oct. 1.3	13.3	5.19*
18.4	15.8	4.90	Nov. 11.3	11.3	5.44
July 5.4	15.8	4.90	23.37	11.3	5.44
10.4	15.3	4.95	1890 Aug. 2.36	13.3	5.19
11.4	15.8	4.90*	Nov. 3.4	5.9	6.07
23.4	15.8	4.90*	4.4	4.3	6.25
Aug. 14.4	15.3	4.95*	5.4	5.3	6.17
23.3	15.3	4.95	6.29	3.9	6.32
Sept. 5.3	14.8	5.02	7.37	5.9	6.07
10.5	15.3	4.95*	10.36	4.4	6.26
Oct. 14.3	14.3	5.07*	14.29	4.3	6.27
20.3	12.3	5.32	16.33	3.9	6.32
21.3	14.3	5.07	Dec. 1.3	5.6	6.14
Nov. 7.25	14.3	5.07	4.25	4.4	6.26
11.25	14.3	5.07*	7.3	5.15	6.18
20.24	14.3	5.07	1891 Sep. 23.37	4.9	6.22

	L.	Mag.		L.	Mag.
1891 Sep. 24.35	9.55	5.70	1891 Nov. 6.30	3.8	6.38
25.36	2.9	6.45	15.29	5.0	6.20
26.36	5.9	6.07	18.31	8.3	5.80
27.31	12.3	5.32	19.32	9.3	5.67
28.29	13.3	5.19	20.31	10.8	5.50
30.3	11.3	5.44	21.25	7.5	5.91
Oct. 1.33	12.3	5.32	25.36	8.6	5.66
3.32	10.8	5.50	27.32	5.8	6.10
5.36	7.3	5.94	30.32	5.8	6.10
8.32	11.3	5.44	Dec. 1.31	6.6	6.02
9.32	11.3	5.44	2.31	8.6	5.75
20.27	10.3	5.57*	3.31	9.3	5.68
21.32	10.3	5.57	5.23	10.3	5.56
25.32	6.8	6.01	8.31	10.8	5.50
28.31	7.3	5.94	10.3	8.3	5.80*
29.31	6.3	6.07	13.26	11.3	5.44*
Nov. 1.33	6.8	6.01	16.32	9.3	5.68
3.33	6.3	6.07	18.26	11.3	5.44
4.33	4.3	6.32	19.29	7.3	5.94

The mark *, appended to an observation, indicates the presence of sufficient moonlight to have a possible effect upon the comparison.

Dorchester, Mass., 1891 *December* 25.

OBSERVATIONS OF THE PERIODIC COMET OF WOLF'S (*b* 1891),

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 9.6-INCH EQUATORIAL,

BY PROF E FRISBY.

[Communicated by the Superintendent.]

1891 Washington M. T.	⁎	No. Comp.	☄ — ⁎ $\Delta\alpha$	☄ — ⁎ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
d h m s			m s	′ ″	h m s	° ′ ″		
Dec. 31 9 58 15.0	1	4 , 13	—4 21.24	+0 26.4	4 14 25.92	—14 15 36.6	*n*8.718	0.848
9 58 45.0	2	4 , 13	—4 27.72	+0 24.6	4 14 25.76	—14 15 33.2		

Mean Places for 1891.0 of Comparison-Stars.

⁎	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	4 18 43.93	+3.23	—14 16 9.5	+6.5	Weisse's Bessel, IV 346
2	4 18 50.25	+3.23	—14 16 4.3	+6.5	" " IV 351

THE BIELA METEORS, 1891,

BY EDWIN F. SAWYER.

Although a repetition of the remarkable meteor showers of Nov. 27, 1872 and 1885 can hardly be looked for until 1898, still a possibility that a few straggling members of this stream might be recorded this year on the date of the nodal passage of the earth and comets' orbits, caused short watches to be taken on the evenings of Nov. 25 and 27, the 26th and 28th being overcast. During an hour's watch, on the evenings mentioned above, only six meteors were observed, the paths of four being accurately noted.

Of the six observed, two were in all probability members of the Biela stream.

At 8^h 40^m Boston M.T. on Nov. 25, a slow-moving, orange-

colored meteor of the second magnitude crossed the square in *Pegasus*, from R.A. 359° + 21° to 353° + 16°, and visible nearly one second. On the 27th, at 6^h 10^m, another slow-moving meteor, also of the second magnitude, passed from R.A. $12\frac{1}{2}$° + 7° to 11° — 1°. The paths of both these meteors traced backwards, passed very near *ν Andromedæ.*

The paths of the other meteors noted on the 27th were from R.A. 25° + 15° to 28° + 11°, second magnitude, at 8^h 45^m, and from R.A. 5° + 33° to 1° + 35°, fourth magnitude, at 8^h 55^m. Both these meteors were also slow moving, and from the direction of δ *Andromedæ.*

Brighton, 1891 *November* 30.

SUN-SPOT OBSERVATIONS,

MADE AT THE HAVERFORD COLLEGE OBSERVATORY WITH THE 8-INCH EQUATORIAL.

BY WM. H. COLLINS.

(Communicated by Prof. LEAVENWORTH, Director.)

1891	Time	Grs	Sps.	Fac Grs	Def. and Size
July 1	4	8	56	0	fair
3	3	6	38	4	fair; 5 lar.
4	8	3	21	2	fair; 2 lar.
5	8	7	50	1	fair; 2 lar.
6	8	6	62	2	fair; 1 lar.
7	8	6	57	2	fair; 3 lar.
9	8	8	62	4	fair; 4 lar.
10	9	9	129	5	fair; 2 lar.
11	9	7	69	1	fair; 5 lar.
12	9	8	99	3	fair; 7 lar.
13	7	8	60	0	bad
14	11	7	83	1	poor; 4 lar.
15	8	7	48	1	poor; 5 lar.
16	11	5	35	1	bad; 5 lar.
17	8	5	32	1	poor; 5 lar.
19	9	6	28	1	bad
21	8	4	42	1	fair; 1 lar.
22	8	6	45	1	fair: 1 lar.
23	10	6	25	1	bad
24	4	6	11	2	bad
25	9	5	11	3	poor
26	9	1	12	0	poor
27	9	3	9	2	bad
29	3	4	16	1	poor
31	10	2	14	1	poor
Aug. 1	9	3	11	1	poor; 1 lar
2	9	2	6	1	bad: 1 lar.
3	10	3	9	0	bad; 1 lar.
4	2	5	25	0	poor
6	9	6	26	1	fair; 3 lar.
7	10	5	27	1	fair; 3 lar.
8	2	5	13	2	fair; 4 lar.
10	8	5	9	2	fair; 1 lar.
11	9	4	18	1	fair; 2 lar.
12	9	4	5	2	fair; 2 lar.
13	9	4	9	1	good; 2 lar.
14	8	3	6	1	good; 2 lar.
15	8	6	17	1	fair; 2 lar.
16	9	4	13	0	fair; 2 lar.
17	11	2	4	1	bad
19	2	0	0	1	bad
20	11	0	0	0	fair
21	4	1	8	2	poor
22	9	3	16	2	good
23	12	1	8	0	fair
27	2	1	4	1	fair
Aug. 28	11	2	7	1	fair
29	9	1	6	0	poor; 1 lar.
Sept. 1	11	3	44	0	fair
2	9	4	59	1	good: 1 lar.
3	9	5	60	1	fair: 1 lar.
4	9	5	58	0	poor
5	3	4	56	0	bad
6	11	6	75	0	bad
7	10	6	106	0	bad
9	10	7	17	0	fair; 3 lar.
10	10	7	15	0	fair: 4 lar.
11	10	1	1	1	poor: 4 lar.
12	10	5	8	0	poor: 4 lar.
13	10	6	26	0	fair: 3 lar.
14	9	4	26	1	fair; 1 lar.
15	9	1	40	0	fair; 1 lar.
16	10	3	64	0	fair; 1 lar.
17	9	3	41	0	poor: 2 lar.
18	11	3	60	0	fair; 2 lar.
19	9	4	52	2	fair: 2 lar.
20	9	5	44	3	poor
21	10	6	37	1	poor
22	10	4	29	2	poor: 1 lar.
23	9	2	12	2	poor: 1 lar.
24	9	2	15	2	poor; 4 lar.
25	10	2	20	0	poor: 2 lar.
26	10	2	25	2	fair; 1 lar.
27	12	3	23	1	fair; 1 lar.
28	11	1	10	2	fair
29	9	3	9	1	bad; 3 lar.
Oct. 5	4	6	36	1	poor
9	9	7	55	2	poor: 3 lar.
11	1	4	22	2	poor
13	1	7	19	2	bad
14	2	4	9	1	poor
15	12	4	9	0	poor
16	10	5	23	1	fair
17	12	3	16	1	bad
20	2	2	21	5	poor
21	9	2	11	2	fair
23	11	1	18	2	poor
24	10	1	11	1	fair
25	9	4	5	1	fair
26	12	2	17	1	fair
27	12	3	20	0	fair
28	10	3	13	2	poor
Oct. 29	2	3	27	3	fair
30	9	3	13	2	poor
31	11	4	22	2	fair
Nov. 1	2	5	30	3	fair
2	9	4	31	2	fair
3	9	4	21	2	fair
4	10	1	26	1	poor
6	10	2	29	0	fair
7	9	2	22	2	poor
8	10	3	29	3	good
9	11	1	36	1	good
11	1	3	15	1	fair
12	11	4	16	1	good: 1 lar.
13	9	2	7	2	fair
14	10	3	14	2	fair
15	10	2	7	1	poor
18	10	4	19	0	fair
19	11	5	52	1	v good: 1 lar
20	10	5	63	0	fair: 5 lar.
21	9	5	79	0	v good: 1 lar
24	2	5	59	1	good: 4 lar.
25	1	1	18	1	good; 3 lar.
27	10	4	18	0	fair: 1 lar.
30	12	3	14	0	bad
Dec. 1	10	3	16	0	poor
2	10	3	11	0	bad
3	10	2	2	0	bad
5	10	1	9	0	bad
6	10	3	15	1	bad
8	11	2	15	2	fair
9	11	3	3	0	bad
10	1	2	4	1	bad
11	9	2	2	0	fair
12	2	2	4	0	poor
13	10	2	4	1	fair
16	10	3	19	1	poor
17	10	3	17	0	poor; 2 lar.
18	10	3	12	1	poor; 3 lar.
19	9	2	12	0	poor; 3 lar.
21	11	1	37	0	poor; 1 lar.
22	12	4	39	0	poor; 1 lar.
23	12	4	61	0	fair
28	11	6	58	3	fair; 2 lar.
29	10	5	16	0	bad
30	10	7	17	3	poor
31	10	7	54	2	fair; 1 lar.

NEW ASTEROIDS.

Two small planets, photographically discovered at Heidelberg, Dec. 22, have been observed at Vienna, as follows:

1891 Dec. 31.3550 Greenw. M.T. $\alpha = 6^h\ 37^m\ 1^s.2$, $\delta = +21°\ 50'\ 22''$. Daily motion, -81^s in α, and $19'$ northward.
1891 Dec. 31.4806 Greenw. M.T. $\alpha = 6^h\ 48^m\ 18^s.2$, $\delta = +18°\ 33'\ 28''$. Daily motion, -60^s in α, and $2'$ northward.

This is probably *Sapientia*, no. 275.

GEORGE BIDDELL AIRY.

The telegraphic cable has brought news of the death of Sir GEORGE AIRY, at the advanced age of 90½ years.

He was born, 1801 July 27, at Alnwick, a market town in the extreme north of England; graduated at the University of Cambridge in 1823; became Professor there in 1826, and Director of the Observatory in 1828. In 1835 he was appointed Astronomer Royal, as successor to POND, and he continued in that position until his resignation in 1881, after forty-six years of assiduous service.

It would be superfluous to tell astronomers of AIRY's services to science, or of the predominant influence in astronomical affairs which he exerted in his own country during more than half a century. To him, more than to all others, have been due the development and tendency of practical astronomy there. The especial characteristics of English instruments and methods of observations, — the training of the majority of English observers, — the organization of almost all the national expeditions for astronomical purposes, — all were strongly imbued with his personality. His, too, was the steady and inflexible resolve with which the chief energies of the Greenwich Observatory have been constantly directed to determining positions of the sun, moon, planets and principal fixed stars, as the primary object of the institution.

The high mathematical ability which marked him as preeminent, even while an undergraduate, has been always manifest in his works. This, combined with a strong taste for engineering and for mechanical problems, gave to English astronomical instruments of the last fifty years their well-known characteristics.

No recapitulation of AIRY's many and important researches is called for here. His discovery of astigmatism and its remedy dates from the time of his scholarship at Trinity College; his discovery of the inequality of long period, in the motions of the *Earth* and *Venus*, was made, and his well-known "Mathematical Tracts" written, while he was in charge of the Cambridge Observatory. In 1839, he devised the method of correcting the deviation of the compass in iron ships. His construction of the double-image micrometer eye-piece, his memoirs on the lunar theory, his masterly treatise on 'Tides and Waves,' would have secured for him a conspicuous place in the history of science, — apart from the principal work of his life in reorganizing and directing the Greenwich Observatory, and the preparation of the numerous planetary and lunar reductions, and of the series of catalogues of stellar positions.

Few astronomers have infused their own individuality so thoroughly into all their work, or impressed it so forcibly upon others as did AIRY. He was a man of exceptional administrative ability, singularly methodical in his habit, and firm in the maintenance of his opinions.

To these mental traits he added yet higher moral ones. Uncompromising integrity and unswerving truthfulness were united in his character with the highest tone of a true gentleman. Such men as he cannot pass through life without incurring hostility, opposition, and sharp criticism, yet he commanded always the admiration of his friends, the esteem of his colleagues, and the respect of his opponents. He was superior to national prejudices, and no element of his character was stronger than his sense of justice. He was the first European to adopt the chronographic method of noting transits and of determining longitudes, and his generous cordiality in affording every desired facility at Greenwich to astronomers from foreign countries, whatever their methods, secured their gratitude, even when their differences of opinion as to these methods were most decided.

In July last, the ninetieth birthday of Sir GEORGE AIRY was appropriately commemorated. A large number of English men of science assembled at Greenwich to testify their respect, and offer their congratulations. At the same time an address, signed by many of his colleagues in continental Europe, was presented to the venerable and honored astronomer.

1892 *January* 6.

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THE ORBIT OF *IAPETUS*.

By A. HALL.

In the years 1875, 1876 and 1877, the orbit of this satellite was situated so that the difference of declination between *Saturn* and *Iapetus* was very small. A glance at the equations of condition for correcting the orbit of a satellite will show that in such a case the determination of the mean distance of the satellite from its primary will depend almost wholly on the differences of right-ascension. For this reason I made a series of observations of *Iapetus*, during the oppositions of *Saturn* in the above years by determining its differences of right-ascension and declination with respect to the planet. The discussion of these observations was published in *Appendix I* of the volume of the Naval Observatory for 1882. The result for the mass of *Saturn* is

$$m = \frac{1}{3481}\,,$$

a value of the mass greater than that found from measures with the heliometer, which is

$$m = \frac{1}{3501}\,.$$

In the year 1889 the orbit-plane of *Iapetus* had returned to a position similar to that of 1875, except that the apparent motion of the satellite was reversed. Hence in this year I began another series of observations with the 26-inch refractor of the Naval Observatory of the differences of right-ascension and declination of *Saturn* and *Iapetus*, and these observations were continued in the opposition of 1890. The transits of the limbs of the planet and of the satellite were recorded on a chronograph, and the differences of declination were measured with a filar micrometer by bisecting the disk of the planet and the satellite. The plan of observing was to take 20 transits, then to turn the micrometer 90° and observe 6 differences of declination, and finally to turn back to the first position of the micrometer and observe again 20 transits. The motion of the satellite being very small in declination, the mean of the times of the transits was taken for the time of the observation: and, from the arrangement of the work, the reduction for motion in declination was generally insensible, except when the observation was interrupted by clouds. In such cases this small correction for motion could be computed safely, and it has been applied in the reductions. The corrections for differential refraction were also very small, hardly ever exceeding 0″.01, and these corrections have been applied. When the satellite was near its conjunctions a change was made in the method of observing. Angles of position and distances were measured with the micrometer, and after being corrected for refraction and motion these quantities were reduced to differences of right-ascension and declination.

The following table gives the results of my observations of this satellite during the oppositions of 1889 and 1890. In the opposition of 1891 my time was taken up by other matters, and these observations had to be omitted. The quantities in the columns C—O are expressed in seconds of arc, and result from a comparison of the observations with my tables for the motion of this satellite, given in the above Appendix. These differences are the independent terms in the equations of condition. In the columns *v* are given the residuals of the equations after substituting the values of the unknown quantities found from the least-square solutions.

Date	Wash. M.T.	$\Delta\alpha$	No. comp.	$\Delta\delta$	No. comp.	C—O in α	C—O in δ	v in α	v in δ	v in	v' in	Remarks
1889	h m	s		″		″	″					
Jan. 2	12 38.0	+ 38.968	12	— 6.12	5	—1.10	+ 1.23	—0.66	+0.57	—0.27	+ 0.60	
3	12 16.8	39.992	40	— 4.98	5	0.52	1.37	0.10	0.68	+ 0.26	0.71	
7	12 11.1	41.776	40	+ 1.97	5	0.68	1.23	0.17	0.16	+ 0.10	0.17	
9	12 7.3	41.181	40	5.91	7	1.29	0.91	0.66	0.13	—0.10	0.13	
10	12 22.7	40.447	40	7.35	5	1.01	1.30	—0.33	0.52	—0.08	0.51	
11	12 12.5	39.170	40	9.05	6	0.78	1.39	+0.01	0.62	+ 0.27	0.60	
12	11 57.1	38.266	40	11.11	6	0.80	1.01	+0.07	0.28	0.35	0.26	
13	11 52.7	36.837	12	+13.16	5	—1.23	+ 0.78	—0.28	+0.05	+ 0.02	+ 0.01	

Date	Wash. M.T.	Δα	No. comp.	Δδ	No. comp.	C — O in α	C — O in δ	v in α	v in δ	v′ in α	v′ in δ	Remarks
1889	h m	s				″	″	″	″	″	″	
Jan. 17	12 15.2	+ 28.686	40	+ 19.03	7	—2.05	+1.03	—0.81	+0.40	—0.37	+0.35	Images blurred
19	11 21.0	23.438	36	21.77	6	1.41	0.65	—0.09	0.10	+0.45	+0.05	A misty sky
22	11 13.1	+ 11.248	42	21.16	7	—1.29	0.40	+0.05	0.00	0.75	—0.06	
27	10 31.2	—37″.41	8	25.00	8	+0.61	0.29	1.71	+0.16	0.56	+0.61	Faint; sky misty
28	12 4.9	90 .16	8	24.44	8	1.08	0.26	2.10	0.19	0.92	0.50	Very faint; sky misty
29	10 48.1	—135 .91	8	23.16	8	+0.47	0.82	+1.12	0.81	0.21	0.99	
Feb. 4	10 21.5	— 27^{s}.488	40	14.78	6	—1.14	+0.37	—0.55	0.66	+0.38	0.66	Misty
6	11 0.7	32.224	40	10.75	6	1.76	—0.04	1.19	0.33	—0.33	0.34	Cold and windy
7	10 40.1	34.218	40	8.28	6	0.59	+0.06	0.00	0.46	+0.82	0.49	Sky misty
9	11 9.6	37.478	38	+ 3.47	6	2.74	—0.31	—2.01	0.16	—1.32	0.19	
11	10 18.1	39.742	44	— 2.00	6	1.83	0.17	0.96	0.34	—0.33	0.39	Unsteady
12	10 6.3	40.441	40	1.73	6	1.95	—0.20	0.97	0.33	+0.39	0.38	[thin clouds
14	10 2.3	40.993	42	10.08	6	2.10	+0.03	1.15	0.59	—0.64	0.65	Faint at times;
18	9 22.3	38.851	40	20.65	6	2.25	—0.58	0.38	0.19	+0.01	0.27	Windy and unsteady
20	8 54.4	36.157	40	25.51	6	3.19	0.17	1.02	0.39	—0.65	0.47	Faint at first; sky misty
23	9 7.5	30.450	40	31.06	6	2.68	0.51	0.14	0.01	+0.25	0.10	Micrometer stiff with cold
25	8 50.8	25.663	40	34.46	6	2.83	0.03	0.12	0.45	0.30	0.51	Faint; sky hazy
26	8 57.8	22.986	40	35.43	6	2.87	—0.20	—0.11	0.25	+0.33	0.35	Cloudy and satellite faint
Mar. 5	8 2.4	—25″.71	8	37.18	8	1.03	+0.68	+1.49	0.87	—0.40	+0.18	Windy and unsteady
6	8 1.8	+ 21 .04	8	36.38	8	1.12	0.41	1.29	0.55	0.45	—0.03	*Rhea* much brighter than *Iapetus*
7	8 18.5	67 .27	8	35.20	8	0.83	+0.31	+1.45	+0.40	—0.13	0.06	
11	9 1.7	+ 17^{s}.244	40	28.20	6	1.94	—0.03	—0.24	—0.15	+0.41	—0.04	
12	8 1.3	19.950	40	26.67	6	1.32	+0.53	+0.24	+0.36	+0.87	+0.47	
17	7 30.9	32.082	40	—13.31	6	1.64	0.39	—0.71	—0.05	—0.22	+0.05	Strong moonl't
22	7 52.3	39.494	40	+ 2.44	6	2.04	0.39	1.48	—0.26	1.13	—0.20	Unsteady
23	7 52.0	40.258	40	4.90	6	1.77	1.14	1.22	+0.45	0.91	+0.51	Faint: sky misty
26	8 12.3	41.104	40	14.79	6	1.15	0.68	0.56	—0.08	0.32	—0.04	
28	8 4.2	+ 40.469	40	+20.49	6	—1.37	+0.78	—0.68	0.00	—0.47	+0.02	
1890												
Jan. 11	13 8.0	— 26.794	20	+36.27	6	—1.73	—0.13	—0.05	+0.19	+0.68	+0.15	Clouds
12	12 49.2	21.454	40	35.68	7	2.82	0.50	1.09	—0.25	—0.32	—0.30	Fuzzy images
13	12 46.8	— 22.048	40	34.07	6	—2.25	—0.09	—0.48	+0.09	+0.33	+0.03	
18	13 35.5	—118″.20	4	23.62	4	+0.17	+1.23	+2.01	1.03	+0.43	0.94	A little mist
21	12 26.0	+ 16 .17	4	16.89	4	—0.58	0.76	1.16	+0.35	—0.20	0.66	Faint
22	12 21.4	61 .09	4	14.83	4	0.01	0.19	1.68	—0.28	+0.40	0.15	Hazy
24	12 2.4	+151 .14	4	9.09	4	0.41	0.48	+1.14	—0.12	0.07	0.57	Haze
26	11 49.5	+ 16^{s}.316	40	+ 2.40	6	1.80	1.59	—0.41	+0.88	0.63	0.78	Cloudy at times; Faint
27	11 56.5	19.188	40	— 0.18	6	2.03	1.35	0.72	0.59	0.29	0.49	[turbed
28	11 53.2	21.924	40	2.65	6	2.08	1.04	0.86	0.24	0.12	0.14	Eye-piece dis-
30	12 0.7	26.998	40	8.36	6	1.76	1.34	0.71	0.46	+0.19	0.36	" "
Feb. 4	11 45.8	36.712	18	20.93	5	1.75	2.17	1.02	1.19	—0.38	1.10	Faint; thin clouds
9	11 10.1	40.937	32	27.65	6	1.12	1.20	0.43	0.24	0.04	0.18	Stopped by clouds
10	11 9.5	41.052	40	28.92	6	1.11	1.52	0.39	0.58	0.03	0.52	[*Saturn*
12	10 54.8	40.521	40	29.83	6	1.32	1.18	0.49	0.30	0.20	0.24	Fuzzy image of
13	10 34.6	39.881	40	30.04	6	1.49	1.11	0.59	0.26	—0.32	0.21	" "
14	10 13.5	38.929	40	30.00	6	1.04	1.00	0.06	0.19	+0.20	0.15	Poor image of
15	10 33.0	37.787	40	29.78	6	1.31	0.92	—0.24	0.15	0.01	0.11	[*Saturn*
16	10 17.8	36.366	40	29.51	6	1.00	1.01	+0.16	0.29	+0.42	0.25	
17	10 19.6	34.786	40	28.93	6	2.08	1.01	—0.82	+0.34	—0.56	0.31	Faint: sky misty
18	10 26.3	32.884	22	. . .	. .	1.96	. . .	—0.60	. . .	—0.33	. . .	Stopped by clouds
20	10 13.6	28.455	10	25.94	6	1.46	0.95	+0.10	—0.15	+0.42	+0.43	
21	10 21.4	25.948	40	24.03	6	1.54	0.40	+0.12	—0.03	+0.47	—0.05	
22	10 57.0	23.274	40	23.00	6	2.60	+0.92	—0.85	+0.56	—0.47	+0.54	Faint: sky hazy
24	10 9.4	+ 17.501	40	18.68	6	1.83	—0.01	+0.06	—0.23	+0.52	—0.25	Poor images
26	9 44.1	+163″.41	4	14.18	4	0.62	—0.63	1.37	—0.71	—0.38	—0.24	
Mar. 2	9 19.5	— 30 .21	4	6.57	4	—0.12	+0.36	1.60	+0.58	0.62	+0.50	Windy
3	9 16.0	79 .30	4	4.35	4	+0.02	0.36	2.01	0.65	0.29	0.44	Hazy
4	9 32.0	—127 .94	4	— 2.12	4	—0.02	+0.36	+1.93	+0.72	—0.44	+0.37	Very cloudy
6	9 26.1	14^{s}.990	40	+ 3.26	6	2.04	—0.71	—0.20	—0.22	+0.52	—0.22	
8	9 1.4	20.872	40	7.07	6	2.13	0.51	—0.43	+0.10	0.28	+0.10	
9	8 46.2	— 23.638	40	+ 8.71	6	—1.47	—0.29	+0.16	+0.38	+0.85	+0.38	

Date	Wash. M.T.	Δα	No. comp.	Δδ	No. comp.	C − O in α	C − O in δ	ε in α	ε in δ	in	in	Remarks
1890	h m	s		″		″	″	″	″			
Mar. 11	9 22.1	− 28.646	40	+12.42	6	−1.79	−0.53	−0.32	+0.23	+0.35	+0.25	Some haze
12	9 29.0	30.822	40	13.33	6	1.98	+0.08	0.58	0.87	+0.06	0.88	[clouds
15	9 22.8	35.917	38	17.85	6	2.92	−0.80	1.69	0.07	−1.12	0.08	Windy and
16	8 23.7	37.166	40	18.03	6	1.98	0.12	0.78	0.76	0.21	0.77	" "
18	8 51.4	38.856	40	19.62	6	2.29	0.39	1.13	0.49	0.63	0.50	Sky misty
19	8 7.3	39.321	32	20.18	6	1.87	0.56	0.71	0.32	0.22	0.33	Clouds
21	7 47.5	39.382	18	20.12	6	2.61	0.18	1.42	0.66	0.95	0.67	Faint : hazy
23	8 22.1	38.454	40	19.91	6	2.25	0.30	0.99	0.48	0.51	0.49	
24	8 1.5	37.600	40	19.38	6	2.46	0.15	1.16	0.60	0.66	0.60	Cloudy at times
26	9 17.6	35.097	40	18.49	6	2.51	0.47	1.09	+0.18	0.56	+0.18	Very unsteady
29	8 17.6	29.872	28	15.91	6	2.60	0.55	1.00	−0.06	0.38	−0.08	Clouds
30	7 46.4	27.779	40	14.75	6	2.56	0.45	0.90	−0.02	−0.25	−0.04	Haze and thin clouds
Apr. 1	7 36.2	23.058	40	11.99	6	2.12	0.11	0.36	+0.18	+0.36	+0.16	Strong moonl't
2	7 38.7	20.450	40	10.70	6	2.29	0.12	0.50	+0.11	0.27	+0.08	Images fuzzy
4	7 36.9	14.923	40	8.01	6	2.38	0.23	0.54	−0.14	0.31	−0.18	Thin clouds
5	7 33.4	− 12.066	40	6.76	6	1.94	−0.38	−0.09	−0.37	0.79	−0.41	
7	7 46.2	− 90″.21	4	3.02	4	0.23	+0.45	+1.61	+0.32	+0.13	+0.10	
8	7 17.2	− 46 .79	4	+ 1.67	4	0.39	0.36	1.42	+0.16	0.00	+0.07	Thin clouds
10	8 20.2	+ 13 .68	4	− 1.07	4	0.62	0.17	1.11	−0.16	−0.16	0.00	Faint : sky misty
11	7 50.7	86 .11	4	2.08	4	0.24	0.11	1.44	0.29	+0.25	+0.01	
12	7 23.2	128 .42	4	3.63	4	0.30	0.01	1.31	0.45	0.22	0.03	
13	7 50.2	+171 .60	4	5.39	4	0.53	0.12	+1.01	−0.10	0.02	0.14	Clouds
18	7 50.9	+ 24s.878	40	11.60	6	1.84	0.89	−0.71	+0.13	0.15	+0.07	
19	7 59.8	27.083	40	12.54	6	1.75	0.86	0.70	0.06	+0.12	0.00	
21	8 2.4	31.006	40	14.50	6	2.21	1.22	1.31	0.36	−0.59	+0.31	
22	7 55.5	32.634	40	15.06	6	1.73	1.09	0.89	0.21	0.22	0.16	Faint at times
25	8 51.1	36.461	40	16.72	6	1.64	1.19	0.94	+0.27	0.42	+0.22	
28	8 13.2	38.273	40	16.86	6	1.77	0.64	1.09	−0.27	0.72	−0.31	Moon 3° away
29	8 6.3	38.101	40	16.93	6	1.41	0.66	0.72	−0.24	0.38	0.28	
30	8 7.7	38.321	40	17.13	6	1.38	0.90	0.66	+0.01	0.36	0.02	
May 2	8 2.8	+ 37.493	40	−16.63	6	−1.65	+0.75	−0.84	−0.09	−0.60	−0.12	

In these observations, the satellite is referred to the center of the planet, and the differences are in the sense of the satellite minus the planet. I am indebted to Ensign H. S. Chase and to Mr. A. Hall, Jr., for assistance in revising my reduction of the observations, and in comparing them with the tables. I am also indebted to Messrs. C. S. McCoy and F. B. Littell, computers in the Naval Observatory, who, through the kind permission of Capt. McNair, completed the comparisons and solved the equations of condition.

The equations for computing the position of the satellite with respect to its primary are

$$\xi = r\cdot\frac{\rho_0}{\rho}\Delta\sin f\sin(F+u)$$

$$\eta = r\cdot\frac{\rho_0}{\rho}\Delta\sin g\sin(G+u)$$

$$\zeta = r\cdot\frac{\rho_0}{\rho}\Delta\sin h\sin(H+u)$$

$$\alpha'-\alpha = s\sin p = \frac{\xi}{1+\zeta}$$

$$\delta'-\delta = s\cos p = \frac{\eta}{1+\zeta}$$

ζ being a small quantity with respect to unity, it is easily disposed of by means of Gaussian logarithms. In these formulas f, F, g, G, h, H, are the auxiliary quantities of Bessel, and depend on the right-ascension and declination of the planet, and the node and inclination of the orbit of the satellite referred to the equator; r is the radius vector of the satellite, u its argument of latitude, ρ the distance of the planet from the earth, ρ_0 the mean distance of *Saturn* from the sun, and Δ is the mean distance of the satellite from the planet when seen at the distance $\rho_0 = 9.53885$.

The equation of condition is

$$a.dE + b.e\,dP + c.de + d.da + e.\sin J\,dN + f.dJ + n = 0,$$

in which dE, dP, de, da, dN, dJ are the corrections to the assumed values of the mean longitude, the longitude of the perisaturnium, the eccentricity, the mean distance, and the node and inclination of the orbit of the satellite referred to the equator; n is the difference C − O, given above. The values of the coefficients in $\alpha'-\alpha$ are as follows:

1889.

$$a = \frac{\rho_0\sin f}{\rho}(0.0002)\left\{\cos(F+u)+(8.4140)\cos(F+302°\ 48'.3)\right\}$$

$$-b = \frac{\rho_0 \sin f}{\rho}(0.0002)\left\{\cos(F+u) + \left[(9.9998)\cos\varepsilon + 0.0139\right] + \cos(F+302^\circ\ 48'.3)\right\}$$

$$c = \frac{\rho_0 \sin f}{\rho}(0.0002)\left\{\cos(F+u)\sin\varepsilon - (9.9998)\sin(F+302^\circ\ 48'.3)\right\}$$

$$d = \xi.(7.2878)$$

$$e = \frac{\rho_0 \sin f}{\rho}(7.6219)\cdot\frac{r}{(2.7122)}\cdot\cos(F+u) - \frac{\rho_0}{\rho}\cos f.\frac{r\cos u}{(2.7122)}$$

$$f = \frac{\rho_0 \sin f}{\rho}(9.2123)\cdot\frac{r}{(2.7122)}\cdot\cos(F+u) + \frac{\rho_0}{\rho}\cos f.\frac{r\sin u}{(2.7122)}$$

In these expressions, ε is the eccentric anomaly of the satellite. The coefficients for the difference of declination are found by putting $\sin g$ for $\sin f$, G for F, and η for ξ. In the coefficients for 1890, we have 302° 51′.0 in place of 302° 18′.3; and the logarithm 7.6118 instead of 7.6219; the rest of the constants remaining the same.

The observations of 1889, give 72 equations of condition, and those of 1890, 125. These observations were made during the winter months, and generally under unfavorable conditions of weather and sky, so that different weights might be assigned to the different days, but in the first solution I have assumed the weights to be equal. In this way, we have the following normal equations:

1889. *Solution A.*

$$\begin{aligned}
+19.5563x - 2.1492y - 0.0006z - 0.1513w + 1.4511u + 3.3021t - 9.1542 &= 0\\
+67.3947y + 45.7216z + 4.6132w + 0.1677u + 0.1230t - 58.1886 &= 0\\
+39.0771z + 1.0849w - 0.2816u + 0.0519t - 50.3070 &= 0\\
+28.5485w + 0.0349u - 1.0126t + 3.1177 &= 0\\
+28.1879u + 0.5442t + 16.6770 &= 0\\
+20.1555t - 3.2364 &= 0
\end{aligned}$$

$[nn] = +120.5611$

1890. *Solution A.*

$$\begin{aligned}
+40.4825x + 18.1745y + 7.9316z - 1.2599w - 0.2728u + 6.8290t - 13.9697 &= 0\\
+162.2207y + 68.5474z + 8.9873w + 0.0025u + 3.5919t - 143.5230 &= 0\\
+40.6177z + 2.0890w + 0.4331u + 1.6770t - 67.7763 &= 0\\
+39.4434w + 0.0944u + 0.3597t - 0.7552 &= 0\\
+38.4013u + 0.2962t + 31.2755 &= 0\\
+12.4190t + 1.2232 &= 0
\end{aligned}$$

$[nn] = +230.8125$

The solutions of the normal equations give,

1889.

$x = +0''.50315 \pm 0''.11965$	$\Delta E = +0^\circ\ 3'.36 \pm 0'.80$
$y = +0.04701 \pm 0.13982$	$\Delta P = +0\ 11.28 \pm 33.55$
$z = +1.25830 \pm 0.18364$	$\Delta N = -0\ 16.54 \pm 2.66$
$w = -0.29073 \pm 0.09743$	$\Delta J = +0\ 0.51 \pm 0.78$
$u = -0.60636 \pm 0.09748$	$\Delta a = -0''.2907 \pm 0''.0974$
$t = +0.07637 \pm 0.11675$	$\Delta e = +0.002441 \pm 0.000356$

1890

$x = -0''.05893 \pm 0''.08598$	$\Delta E = -0\ 0'.39 \pm 0'.57$
$y = +0.63950 \pm 0.07819$	$\Delta P = +2\ 33.43 \pm 18.76$
$z = +0.62157 \pm 0.15442$	$\Delta N = -0\ 22.37 \pm 2.31$
$w = -0.15848 \pm 0.08458$	$\Delta J = -0\ 0.61 \pm 0.55$
$u = -0.82082 \pm 0.08478$	$\Delta a = -0''.1585 \pm 0''.0846$
$t = -0.09093 \pm 0.08174$	$\Delta e = +0.001206 \pm 0.0002995$

The solutions of the normal equations give the unknown quantities in seconds of arc, and as the semi-major axis of the orbit of this satellite was put equal to unity, where $a = 515''.5195$, the resulting values, need to be multiplied by the number 6.6685 to furnish the corrections to the angular quantities in minutes of arc. For the control we have

1889.

$[nn.6] = 38.656$; probable error of an equation $= \pm 0''.516$
$\Sigma.\,p\,v^2 = 38.648$; 72 equations

1890.

$[nn.6] = 72.061$; probable error of an equation $= \pm 0''.525$
$\Sigma.\,p\,v^2 = 72.153$; 125 equations

In the observations of this satellite, made fifteen years ago, the average probable error of an equation was ±0″.316, from 248 differences found with the chronograph. The increase of this error in the recent work may arise partly from the fact that these observations were made during the winter months, when the images are generally poor; but an examination of the residuals shows a systematic difference between the measurements made with the filar micrometer and those got from the chronograph. Since the first were made near conjunctions, when the satellite was faint, and the Ring of the planet may have introduced a constant error into the measurements, another solution has been made, omitting the observations near conjunctions. The normal equations and their solutions are now as follows:

1889. *Solution B.*

$$\begin{array}{rrrrrrrl}
+11.6365\,x & -\ \ 1.1457\,y & -\ \ 0.5251\,z & -\ \ 0.8661\,w & +\ \ 1.4134\,u & +\ \ 1.9826\,t & -\ \ \ 3.2745 & = 0\\
 & +\ 15.7018\,y & +\ 31.1375\,z & +\ \ 5.4210\,w & +\ \ 0.1917\,u & +\ \ 0.1569\,t & -\ 57.3545 & = 0\\
 & & +\ 29.0062\,z & +\ \ 4.5175\,w & -\ \ 0.3106\,u & -\ \ 0.0440\,t & -\ 18.6241 & = 0\\
 & & & +28.4019\,w & +\ \ 0.0349\,u & -\ \ 0.7105\,t & +\ \ \ 3.6024 & = 0\\
 & & & & +\ 28.0980\,u & +\ \ 0.3822\,t & +\ 17.0437 & = 0\\
[nn] = +\ 114.2501 & & & & & +\ 12.0467\,t & -\ \ \ 2.4755 & = 0
\end{array}$$

1890. *Solution B.*

$$\begin{array}{rrrrrrrl}
+23.6000\,x & +\ \ \ 6.2529\,y & +\ \ 2.9802\,z & +\ \ 2.2381\,w & -\ \ 0.3358\,u & +\ \ 4.0266\,t & -\ \ 11.6474 & = 0\\
 & +\ 103.5181\,y & +\ 41.5637\,z & +\ \ 7.7278\,w & -\ \ 0.0411\,u & +\ \ 1.4170\,t & -\ 134.6070 & = 0\\
 & & +\ 30.1953\,z & +\ \ 1.7106\,w & +\ \ 0.3829\,u & +\ \ 0.6694\,t & -\ \ 64.1220 & = 0\\
 & & & +\ 38.8503\,w & +\ \ 0.0388\,u & -\ \ 0.0291\,t & -\ \ \ 0.2514 & = 0\\
 & & & & +\ 37.0923\,u & -\ \ 3.3089\,t & +\ \ 30.9576 & = 0\\
[nn] = +\ 225.0072 & & & & & +\ 25.1209\,t & -\ \ \ 2.5057 & = 0
\end{array}$$

Hence, we have for the values of the corrections to the elements,

1889.

$$\begin{array}{llll}
x = +0''.40691 \pm 0''.10111 & \Delta E = \ \ \ 0^\circ\ \ 2'.71 \pm \ 0'.67\\
y = +0.48220 \pm 0.09676 & \Delta P = +1\ \ 55.69 \pm 23.21\\
z = +1.22144 \pm 0.12239 & \Delta N = -0\ \ 16.86 \pm \ 1.75\\
w = -0.39671 \pm 0.06438 & \Delta J = +0\ \ \ 0.89 \pm \ 0.66\\
u = -0.61815 \pm 0.06401 & \Delta a \ = -0''.3967 \qquad \pm 0''.06438\\
t\ = +0.13291 \pm 0.09892 & \Delta e \ = +0.00023693 \pm 0.00023741
\end{array}$$

1890.

$$\begin{array}{llll}
x = +0''.12159 \pm 0''.06368 & \Delta E = +0^\circ\ \ \ 0'.83 \pm \ 0'.42\\
y = +1.07116 \pm 0.04837 & \Delta P = +4\ \ 16.99 \pm 11.60\\
z = +0.55617 \pm 0.09045 & \Delta N = -0\ \ 23.10 \pm \ 1.36\\
w = -0.22314 \pm 0.04870 & \Delta J = -0\ \ \ 0.72 \pm \ 0.11\\
u = -0.84738 \pm 0.04942 & \Delta a \ = -0''.2231 \qquad \pm 0''.04870\\
t\ = -0.10731 \pm 0.06088 & \Delta e \ = +0.0010788 \pm 0.0001755
\end{array}$$

The control equations are now,

1889.

$[nn.6] = 13.576$: probable error of an equation $= \pm 0''.328$

$\Sigma . p\, e^2 = 13.569$: 60 equations

1890.

$[nn.6] = 17.800$: probable error of an equation $= \pm 0''.299$

$\Sigma . p\, v^2 = 17.898$: 97 equations

The average probable error of an equation in the solution *B* is ±0″.314, or the same as fifteen years ago. The increase of the probable error shown in the first solution, comes therefore wholly from the systematic difference between the two kinds of measurement. The observations with the filar micrometer made near the conjunctions have very little weight for most of the elements, but may be of use for determining the longitude of the satellite, and the inclination of its orbit. The equations from these measurements during the two years have therefore been put together and give the following normals:

1889 and 1890.

$$\begin{array}{rrrrrrrl}
+\ 24.8023\,x & +\ 10.9181\,y & +\ \ 5.1759\,z & +\ 1.6930\,w & +\ 0.1007\,u & +\ \ 1.1219\,t & -\ 8.2020 & = 0\\
 & +\ 80.3955\,y & +\ 38.5708\,z & +\ 0.4487\,w & +\ 0.0196\,u & +\ \ 2.1410\,t & -\ 9.7501 & = 0\\
 & & +\ 20.1933\,z & -\ 0.0542\,w & +\ 0.0792\,u & +\ \ 1.1035\,t & -\ 5.3372 & = 0\\
 & & & +\ 0.7397\,w & +\ 0.0556\,u & +\ \ 0.0867\,t & -\ 0.9885 & = 0\\
 & & & & +\ 1.3989\,u & +\ \ 3.7682\,t & -\ 0.0188 & = 0\\
[nn] = +\ 12.1196 & & & & & +\ 25.1369\,t & +\ 2.9680 & = 0
\end{array}$$

The solution gives,

$$\begin{array}{llll}
x = +0''.28053 \pm 0''.07192 & \Delta E = +0^\circ\ \ \ 1'.87 \pm \ 0'.48\\
y = -0.09911 \pm 0.11396 & \Delta P = -0\ \ 23.86 \pm 27.31\\
z = +0.38691 \pm 0.21436 & \Delta N = +0\ \ 19.53 \pm \ 9.32\\
w = +0.76190 \pm 0.10808 & \Delta J = -0\ \ \ 1.86 \pm \ 0.54\\
u = +0.71608 \pm 0.31166 & \Delta a \ = +0''.7161 \qquad \pm 0''.31166\\
t\ = -0.27921 \pm 0.08107 & \Delta e \ = +0.0007505 \pm 0.0004352
\end{array}$$

$[nn.6] = 7.106$: probable error of an equation $= \pm 0''.308$

$\Sigma . p\, e^2 = 7.108$: 40 equations.

The different solutions all give small corrections to the mean longitude of the satellite, and indicate that my former values of this element and of the mean motion, or the periodic time, are nearly correct. In such an orbit, the position of the perisaturnium is naturally uncertain. For the final corrections of my previous elements, I conclude to adopt the mean values of solution *A*, in which all the observations have been employed. The systematic differences in the observations increase the probable errors of this solution, but on the whole it appears to [illegible]

This increase is well shown by the second columns of residuals ε', in which are given the results of substituting in the equations of condition the values of the corrections found from the solutions B, and 1889 and 1890. The adopted values of the corrections are,

$$\Delta E = +0^\circ\ 0'\ 0.88 \pm 0.47$$
$$\Delta P = +1\ 59.58 \pm 16.37$$
$$\Delta N = -0\ 19.87 \pm 4.74$$
$$\Delta J = -0\ \ 0.24 \pm 0.15$$
$$\Delta a = -0''.2153 \pm 0''.06387$$
$$\Delta e = +0.0017173 \pm 0.00022926$$

These corrections applied to the elements of the satellite for 1880 give the following new elements of the orbit. These elements are referred to the meridian of Greenwich, since for a long time the data given in the *American Ephemeris* were not convenient for reductions of this kind, and even with the recent improvements it is still easier to use the *English Nautical Almanac*, or the *Conn. des Temps*.

Washington, 1892 *January* 2.

ELEMENTS OF *Iapetus*.

Epoch, 1890.0 Greenwich M.T.

$$\left.\begin{array}{lrrr} E = & 54^\circ & 29' & 23''.0 \\ P = & 355 & 28 & 51.1 \\ n = & 142 & 6 & 52.7 \\ i = & 18 & 27 & 0.8 \end{array}\right\} \text{Mean Eq. 1890.0}$$

$$a = 515''.304 \pm 0''.061$$
$$e = 0.0295123$$

Periodic Time = 79.3310152 mean solar days.

These elements give for the mass of *Saturn*

$$m = \frac{1}{3485.7 \pm 1.28}$$

SUNSPOT OBSERVATIONS,

MADE AT PHILADELPHIA, PENN., WITH A 4.5-INCH REFRACTOR,

BY A. W. QUIMBY.

1891	Time	New Grs.	New Sps.	Total Grs.	Total Sps.	Fac. Grs.	Def.
July 1	10	1	–	4	40	2	poor
3	9	–	–	1	16	2	fair
4	7	–	–	2	26	1	fair
5	7	1	3	3	20	3	good
6	7	–	–	3	32	1	good
7	7	–	–	3	33	4	good
9	7	3	–	5	72	1	good
10	7	–	–	1	81	3	good
11	4	1	1	1	66	4	good
12	7	–	–	1	61	4	fair
13	7	1	–	5	148	2	good
14	7	–	–	1	71	2	poor
15	7	–	–	3	150	–	poor
16	7	–	–	3	72	1	fair
17	7	–	–	3	48	2	fair
18	2	1	3	3	34	2	poor
19	7	1	1	4	116	4	good
20	7	–	–	4	82	2	fair
21	7	–	–	3	64	2	fair
22	7	1	–	1	65	2	fair
23	7	–	–	1	40	–	poor
24	9	–	–	4	20	–	poor
25	7	–	–	3	11	–	fair
26	7	–	–	1	16	4	fair
27	7	2	8	3	19	6	fair
28	7	–	–	3	10	–	poor
29	8	–	–	3	11	3	poor
30	7	–	–	3	30	4	fair
31	7	–	–	2	31	3	fair
Aug. 1	7	1	–	2	27	3	fair
2	7	–	–	2	16	2	poor
3	7	–	–	2	20	2	fair
Aug. 4	7	3	–	5	30	2	fair
5	7	–	–	3	–	–	v. poor
6	7	–	–	3	49	2	good
7	7	–	–	3	20	4	fair
8	7	2	–	5	25	4	fair
9	1	–	–	2	8	–	good
10	7	–	–	3	16	3	good
11	7	–	–	3	50	6	good
12	7	–	–	3	32	4	fair
13	7	–	–	2	16	4	fair
14	7	–	–	2	10	1	fair
15	7	1	–	3	9	3	poor
16	7	–	–	3	10	3	fair
17	7	–	–	2	16	3	fair
18	6	–	–	2	5	1	poor
19	7	–	–	1	7	2	fair
20	7	–	–	1	5	1	poor
21	7	–	–	1	8	2	poor
22	7	2	–	3	16	2	fair
23	7	–	–	3	15	2	fair
24	7	–	–	2	20	4	fair
25	10	–	–	2	5	3	poor
26	2	–	–	2	8	1	poor
27	4	–	–	2	7	1	poor
28	11	1	5	2	11	1	poor
29	7	–	–	2	16	2	poor
31	8	1	1	2	40	1	fair
Sept. 1	8	–	–	2	107	3	fair
2	8	2	–	2	251	4	v. good
3	2	1	–	4	121	4	poor
4	10	–	–	4	189	4	fair
5	9	1	–	5	149	3	poor

1891	Time	New		Total		Fac.	Def.
		Grs.	Sps.	Grs.	Sps.	Grs.	
Sept. 6	12	_	_	5	195	3	poor
7	11	_	_	5	93	4	poor
8	7	_	_	5	91	3	fair
9	9	_	_	5	63	3	fair
10	8	1	_	5	39	3	fair
11	8	_	_	4	9	3	poor
12	3	1	_	5	15	3	fair
13	8	1	_	6	33	2	fair
14	8	_	_	4	23	3	fair
15	8	2	_	4	57	3	fair
16	6	_	_	3	31	_	poor
17	8	_	_	3	88	_	fair
18	_	_	_	3	78	3	fair
19	8	1	1	4	44	2	fair
20	8	1	2	5	13	5	poor
21	8	1	1	6	38	1	fair
22	8	_	_	3	32	3	fair
23	8	1	1	3	30	3	fair
24	8		_	2	32	2	fair
25	10	_	_	2	19	2	fair
26	8	1	9	2	31	2	fair
27	1	_	_	3	32	2	fair
28	8	1	1	3	47	1	fair
29	9	1	1	3	27	2	poor
30	8	_	_	3	16	3	poor
Oct. 1	8	_	_	5	22	1	poor
2	12	1	1	6	27	4	poor
3	10	_	_	6	91	3	good
4	8	1	4	7	63	2	fair
5	8	_	_	7	73	2	fair
6	9	_	_	6	35	2	poor
8	9	1	2	7	105	3	fair
9	8	_	_	7	81	3	fair
10	8	_	_	4	32	_	poor
11	1	_	_	6	16	2	fair
13	1	_	_	4	15	2	v. poor
14	1	2	2	1	8	2	poor
15	2	_	_	4	11	2	poor
16	8	_	_	3	23	2	fair
17	3	_	_	3	32	2	fair
18	9	_	_	2	14	_	v. poor
19	8	_	_	2	15	_	v. poor
20	3	1	2	2	23	2	poor
21	9	1	1	3	13	2	fair
23	10	2	2	4	12	2	fair
24	9	_	_	1	11	2	fair
25	8	_	_	4	5	2	poor
26	10	1	_	3	22	1	fair
27	10	_	_	2	21		fair
28	8	_	_	2	9	3	poor
29*	9	2	5	1	63	6	good
30	9	_	_	3	22		poor
31	8	_	_	3	26	3	fair

1891	Time	New		Total		Fac.	Def.
		Grs.	Sps.	Grs.	Sps.	Grs.	
Nov. 1	8	_	_	3	19	3	fair
2	9	_	_	3	26	3	fair
3	2	1	1	3	38	3	fair
4	2	_	_	3	49	3	fair
6	2	_	_	3	42	3	fair
7	8	_	_	3	32	2	fair
8	2	_	_	2	32	3	poor
9	2	_	_	2	27	1	poor
10	9	_	_	2	11	_	v. poor
11	2	1	1	3	21	2	fair
12	10	_	_	3	14	3	fair
13	10	1	1	4	5	4	fair
14	9	_	_	3	6	4	fair
15	9	1	3	4	9	3	fair
18	9	_	_	4	34	2	fair
19	9	_	_	4	88	2	good
20	9	_	_	4	82	2	good
21	9	_	_	4	59	3	fair
22	2	_	_	2	37		poor
23	11	_	_	2	30	_	v. poor
24	9	_	_	2	47	1	fair
25	10	_	_	2	8	1	v. poor
26	9	_	_	2	6	2	v. poor
27	10	2	7	4	11	2	fair
28	10	_	_	3	13	_	poor
30	8	_	_	2	11	3	fair
Dec. 1	8	_	_	2	15	4	fair
2	9	_	_	2	8	3	fair
3	10	_	_	2	2	3	fair
4	10	_	_	2	8	3	fair
5	10	_	_	1	5	2	fair
6	9	1	1	3	11	2	fair
8	8	_	_	2	8	2	poor
9	9	_	_	2	5	3	poor
10	9	_	_	2	7	3	fair
11	9	_	_	2	4	3	fair
12	10	1	1	2	7	4	fair
13	10	_	_	1	2	3	fair
14	9		_	1	3	1	poor
15	2	1	2	2	3	_	v. poor
16	10	_	_	3	15	3	fair
17	10	_	_	3	18	4	fair
18	10	_		3	10	4	fair
19	10	1	3	1	17	2	fair
20	2	_	_	3	19	2	poor
21	2	1	4	4	14	2	fair
22	1		_	4	85	4	fair
23	10			4	86	2	fair
24	3	_		2	33		poor
27	1	1	5	5	36	4	fair
28	1			5	43	4	[illegible]
29	10			4	19		poor
30	4	2	11	7	63	8	good
31	10	_		7	61	4	good

* With 9.5 Princeton.

ELEMENTS AND EPHEMERIS OF THE PERIODIC COMET OF WOLF.

From a letter of Mr. Berberich to the Editor.

In the *Astronomical Journal*, no. 238, you gave account of my elements of Wolf's periodic comet, and I therefore assume that the following lines may be of some [illegible] to you and the readers of your Journal. My [illegible]

exclusively upon the observations made by Prof. SCHUR, with the great refractor of the Strassburg Observatory, and were referred to the present apparition by adding the perturbations produced by the planet *Jupiter*. I have now further computed the perturbations by *Saturn* from 1884 to 1891, which also attain a considerable amount.

$$
\begin{aligned}
IM &= +2'\ 16''.19\\
I\omega &= -0\ \ 18.06\\
I\Omega &= -0\ \ \ 7.99\\
Ii &= +0\ \ \ 0.15\\
I\phi &= +0\ \ \ 1.66\\
I\mu &= +0''.00470
\end{aligned}
$$

Having regard to these variations the difference between observation and computation at rediscovery is diminished to $+8^s$. This error will disappear by a correction in the mean anomaly of about 0′.5. Introducing the quantity $\partial\mu = +0''.011$ into the equations of condition in the first apparition, the corrections of the other elements become

$$\partial M_0 = +0''.43\,; \quad \partial\omega_1 = -1''.30\,; \quad \partial\phi = -1''.76$$

(the epoch for M is the perihelion time 1884 Nov. 17.8)

The residuals in the eight normal places in longitude are now

			″				″
I	1884	Sept. 23	0.0	V	1885	Jan. 14	+1.2
II		Oct. 21	−0.2	VI		Feb. 8	−2.1
III		Nov. 8	−0.4	VII		Mar. 14	+1.1
IV		Dec. 14	+0.8	VIII		Apr. 2	−1.1

(N. P. IV has been corrected by +1″.8 and +0″.8 in longitude and latitude respectively.)

This agreement might be still regarded as quite satisfactory. The good result of the whole computation proves the excellent qualities of the telescope in the hands of a skillful and active observer.

Taking together the above variations, we obtain the following elements for WOLF's comet in its second apparition.

Epoch 1891 Sept. 8.0 Berlin M.T.

$$
\begin{aligned}
M &= \ \ \ 0^\circ\ 39'\ 12''.4\\
\omega &= 172\ \ 18\ \ 28.0\\
\Omega &= 206\ \ 21\ \ 27.5\\
i &= \ \ 25\ \ 14\ \ 37.6
\end{aligned}
\Bigg\}\ \text{M. Eq. 1890.0}
$$

$$
\begin{aligned}
\phi &= \ \ 33\ \ 51\ \ 25.7\\
\mu &= 520.2536\\
\log a &= 0.5558610
\end{aligned}
$$

Any further improvement of this orbit might be postponed until the next return of the comet, in 1898, as the perturbations during the new revolution will be very small, and therefore the mean motion, that most important element, will be known with all desirable exactness by combining 1891 and 1898. From the following rough ephemeris you may perceive that the comet will be observable in 1898–99 through many months; the perihelion takes place on June 30.

Date			α	δ	log Δ	log r	Br.
			h m	° ′			
1898	June	3	1 42.3	+18 18	0.343	0.208	1.7
	July	5	3 18.3	+19 43	0.306	0.202	2.1
	Aug.	6	4 49.3	+16 51	0.271	0.214	2.3
	Sept.	7	6 4.9	+10 2	0.236	0.240	2.4
	Oct.	9	6 56.9	+ 0 38	0.199	0.274	2.4
	Nov.	10	7 17.9	− 9 21	0.167	0.312	2.4
	Dec.	12	7 4.1	−16 20	0.161	0.350	2.1
1899	Jan.	13	6 34.1	−16 31	0.205	0.386	1.4
	Feb.	14	6 21.4	−11 31	0.292	0.419	0.8

The unit of brightness is that of 1891 May 1.

In the later returns, the position of the comet remains unfavorable, nevertheless observations could be secured by the giant telescopes at Mt. Hamilton and Mt. Wilson about the apparitions preceding or following the perihelion passages. Since seven revolutions of the comet are nearly equal to three of *Jupiter*, a second approach of these two bodies will occur in 1922–23, depriving us perhaps of the sight of the comet for a long time, if not forever.

A. BERBERICH.

Berlin, 1892 *January* 3.

NEW ASTRONOMICAL WORK.

Astronomy and Astrophysics.

The *Sidereal Messenger*, which has for ten years been published by Prof. WILLIAM W. PAYNE, at Northfield, Minnesota, and has rendered valuable services in diffusing astronomical knowledge, has celebrated the completion of its hundredth number by enlarging both its field and its dimensions.

It has now taken the new title, *Astronomy and Astrophysics*, although the numeration of its issue is continued — the first of the new series bearing the number 101. The astrophysical portion is under the direction of Prof. GEORGE E. HALE of Chicago; and promises to give not only communications from home sources, but also translations of the most important articles regarding spectroscopy and celestial physics which may be published in foreign languages.

The periodical is embellished with elegant illustrations.

CONTENTS.

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PROPER MOTIONS OF 27 SOUTHERN STARS.

By LEWIS BOSS.

In the intervals of other work, during the past two or three years, I have been collecting a list of stars hitherto supposed to exhibit a secular proper motion in each case of 10″ or more. This list now contains the positions and precessions for 1850 and 1900, as well as the approximate proper motions, of something more than 2700 stars, but is yet by no means complete. The preponderance of stars in the Northern hemisphere known to be affected with sensible proper motion, is very great over the corresponding class of stars for the Southern hemisphere. Since the ultimate object of any such collection is, naturally, the study of solar motion in space and problems of a similar nature, the lack of symmetry in the distribution of these stars affords no pleasing prospect of escape from the systematic errors, as well as the indeterminateness, always inherent in general discussions of this kind.

The subjoined list of 27 stars, having annual proper motions mostly greater than 0″.40, and not included in the general list to which allusion has been made, is the first fruit of an attempt to offer a partial remedy for this defect of asymmetry in the distribution of stars of known proper motion. The stars of this list are taken as the most notable cases, from a much larger collection.

To many of these stars proper motions are assigned in the Catalogue of the British Association for 1850; but since the proper motions there attributed to this class of stars are merely the proportional differences for one year between the positions derived from the zone observations of Lacaille, and the corresponding positions taken from Brisbane or Taylor, they are almost of no value at all in the search for actual cases of sensible proper motion.

Twelve of the stars in the list here presented, appear to have annual proper motions equal to, or greater than, 0″.50. The results of computation for these are, therefore, presented in separate tables for each star. These illustrate the manner in which the computations have been made for the entire list. They also fairly indicate the uncertainty which remains in the determination. The plan of computation was to form preliminary positions, precessions, and secular variations for 1850 and 1900, together with preliminary values of the proper motion, and then to correct these with such rigor of computation as might seem desirable. The seconds of right-ascension and declination for 1850, computed with the finally adopted quantities of precession and proper motion, are given as they result from each catalogue place unchanged, except in the case of Brisbane's Catalogue, in which instance, corrections derived from the table at page 260 of the appendix, were regarded as part of the Catalogue Right-Ascension.

In deriving the proper motions, systematic corrections were employed in some cases. The most notable of these are the large corrections for right-ascensions required by the Madras Catalogues. These were taken from Argelander's discussion in the seventh volume of Bonn Observations. Otherwise there is a general attempt to produce approximate conformity with the system of the *American Ephemeris*. The positions from Lacaille are presented for purpose of comparison. In a very few cases, however, his right-ascensions were given a nominal weight.

L. 75. $\mu = -0^s.019$, $\mu' = -0''.31$

1850			0ʰ 17ᵐ	−51° 51′
Lacaille	1752	1	20.1	93
Brisb.	1821	1–2	17.49	51.9
Taylor	35	3	18.88	53.6
Cape	53–51	2–4	18.26	53.8
C. Z.	73	1	18.31	52.9
Gould	76	1	18.31	53.0
Gould	77	5	18.39	52.5
Stone	77	3	18.07	51.2
Melb.	77	3	18.14	53.2
Adopted:			**18.25**	**53.1**

L. 239. $\mu = +0^s.055$, $\mu' = +0''.07$

1850			0ʰ 45ᵐ	−31° 10′
Lacaille	1752	1	38.9	5
Wn. Z.	1847	1	37.72	32.1
A. Z.	51	2	38.22	28.7
Yarnall	61–74	3–4	38.29	30.2
C. Z.	73	3	38.31	28.1
Gould	71	2	38.31	29.1
Gould	75	1	38.30	28.1
Stone	79	3	38.16	29.1
Adopted			**38.26**	**28.9**

L. 2950. $\mu = -0^s.001$, $\mu' = -0''.57$

1850			7ʰ 58ᵐ	−44° 47′
Lacaille	1752	1	21.1	52
Brisb.	1824	6–5	19.29	43.2
Cape	40	0–2	–	41.5
Cape	52	2–3	18.55	41.8
Moesta	60	1	18.47	[illegible]
C. Z.	71	2	18.54	[illegible]
Gould	71	1	18.61	41.7
Gould	75	3	18.56	42.2
Stone	77	3	18.45	[illegible]
Adopted			**18.53**	**41.3**

L. 3122. $\mu = +0^s.076$, $\mu' = +0''.07$

1850			$7^h\ 54^m$	$-59°\ 54'$
			s	
Lacaille	1752	1	59.9	21
Brisb.	1824	3–4	60.01	14.5
Taylor	35	3	60.65	5.9
Cape	40	0–3	–	7.6
Cape	52	2–0	60.40	–
Jacob	53	1	60.31	5.6
Moesta	55	1	60.07	5.0
C. Z.	73	1	60.22	6.3
Stone	75	3	60.16	7.1
Gould	75	6	60.25	6.6
Adopted:			**60.21**	**6.8**

L. 5123. $\mu = -0^s.127$, $\mu' = +0''.20$

1850			$12^h\ 15^m$	$-66°\ 48'$
			s	″
Lacaille	1752	1	9.4	34
Brisb.	1824	1	[18.15]	39.3
Gilliss Z.	52	3	12.30	34.3
Cape	52–51	2–3	12.59	33.7
C. Z.	74	3	12.50	34.6
Gould	74	5	12.56	35.3
Stone	74	3	12.26	35.8
Adopted:			**12.45**	**34.6**

L. 5892. $\mu = -0^s.030$, $\mu' = +0''.31$

1850			$14^h\ 10^m$	$-25°\ 7'$
			s	″
Lacaille	1752	1	31.0	55
Brisb.	1824	1	31.07	63.9
Wn. Z.	48	1	30.60	67.1
A. Z.	50	2	30.91	65.2
Jacob	51	1–5	31.22	65.1
Cape	52–50	2–1	30.91	66.0
Yarnall	66	2	31.05	68.4
Gould	74	4	30.95	65.6
Stone	78	3	30.97	65.1
Sydney	78	5	30.97	65.7
Adopted:			**30.96**	**65.5**

L. 6521. $\mu = -0^s.0351$, $\mu' = -0''.279$

1850			$15^h\ 37^m$	$-57°\ 26'$
			s	″
Lacaille	1752	1	15.8	0
Vidal	1799	?	15.65	0.9
Brisb.	1824	1	14.91	8.7
Wn. Z.	50	1	15.66	10.8
Jacob	51	5	15.93	9.3
Cape	52–50	2–1	15.77	9.6
Jacob	55	2	45.81	8.9
Gould	75	3	45.70	9.0
C. Z.	75	1	15.58	8.1
Gould	78	2	15.65	9.5
Stone	78	3	45.76	8.1
Wn. T.C.	81	3	45.63	10.0
Adopted:			**45.68**	**9.1**

L. 8267. $\mu = +0^s.163?$ $\mu' = -0''.68$

1850			$19^h\ 50^m$	$-67°\ 42'$
			s	″
Lacaille	1752	1	29.8	0
Bb. (M)	1824	5–12	27.66	12.8
Bb. (Tr.)	1824	2–0	25.69	–
Cape	51	0–2	–	14.1
Gilliss Z.	53	1	28.40	13.1
C. Z.	73	1	28.24	12.9
Gould	75	4	28.08	13.5
Stone	75	3	27.96	13.1
Adopted:			**28.02**	**13.4**

L. 8625. $\mu = +0^s.105$, $\mu' = -0.''38$

1850			$20^h\ 53^m$	$-73°\ 45'$
			s	′ ″
Lacaille	1752	1	33.6	44 42
Gilliss Z.	1852	2	31.82	45 12.6
Cape	53–51	2	31.46	12.0
C. Z.	74	1	31.68	9.8
Gould	75	3	31.62	11.2
Stone	75	3	31.54	12.1
Gould	79	2	31.63	12.5
Gould	83	4	31.52	12.4
Adopted:			**31.56**	**12.1**

L. 8733. $\mu = +0^s.067$, $\mu' = -0.''13$

1850			$21^h\ 6^m$	$-61°\ 57'$
			s	′ ″
Lacaille	1752	1	14.7	56 52
Jacob	1850	1	15.83	57 26.4
Cape	51	0–2	–	26.0
Melb.	67	3	15.47	26.2
C. Z.	74	1	45.43	25.2
Stone	76	3	45.40	26.3
Gould	76	1	45.47	26.3
Adopted:			**45.44**	**26.3**

L. 9076. $\mu = +0^s.050$, $\mu' = -0''.68$

1850			$22^h\ 8^m$	$-54\ 20$
			s	″
Lacaille	1752	1	24.1	43
Jacob	1850	4–5	21.04	47.4
Gilliss	51 ?	1	23.54	47.1
Cape	53–51	1–2	23.62	46.0
Moesta	55	2	23.41	47.9
C. Z.	73	2	23.37	45.6
Gould	75,	3	23.68	47.7
Stone	77	3	23.45	47.1
Gould	79	2	23.50	45.4
Adopted:			**23.56**	**46.7**

L. 9396. $\mu = +0^s.0728$, $\mu' = -0''.399$

1850			$23^h\ 4^m$	$-63°\ 29'$
			s	″
Lacaille	1752	1	52.0	16
Brisb.	1824	4–7	48.60	53.6
Cape	38	3–0	18.64	–
Cape	51	0–3	–	50.4
Jacob	53	4	49.08	50.8
Moesta	60	1	48.82	50.2
C. Z.	74	2	48.76	50.0
Gould	75	4	48.72	50.9
Stone	76	3	48.62	51.1
Adopted:			**48.66**	**51.0**

It will be noticed that the star, Lacaille 8267, exhibits an apparent annual proper motion greater than 1″; though its exact amount may still be regarded as uncertain by nearly one-tenth of the total motion. A few good observations at the present time would in this, as in scores of other cases, reduce the uncertainty to one-third or less of its present amount.

This case well illustrates the deplorable uncertainty of the right-ascensions of the Paramatta Catalogue. The writer joins most heartily in the opinions expressed by Mr. Stone in the introduction of the Cape Catalogue for 1880, that a new reduction of the Paramatta observations by purely differential processes, on the basis of ample material now available, would probably furnish results of much greater usefulness than the comparatively worthless right-ascensions now available in Richardson's reduction. It is very much to be wished that the custodians of the original records of the Paramatta Observations (if these records are still in existence), would cause an adequate examination of them to be made, to ascertain the feasibility and probable value of a new reduction in the manner suggested. The late Mr. Pogson notified his intention of undertaking a new reduction of Taylor's Madras observations, which, it is hoped, will be carried out by his successor. It is not improbable that a new reduction of Piazzi's observations upon a differential basis may be undertaken in the near future. I am strongly of the opinion that the accomplishment of these three works would prove a wise expenditure of labor, and that it would place the determination of proper motion for southern stars, at least, upon a vastly improved basis.

It is assumed, for the present, that the stars move across the sky uniformly, in the arc of a great circle; and in that case their motions, resolved into motions of right-ascension and declination, cannot be uniform. Consistency therefore requires that this variation from uniformity be taken into

account, whenever it is distinctly sensible. This is the more important, because its effects are practically systematic in the discussion of any problem founded upon the use of a large number of proper motions. The secular variations of the proper motion in the respective coordinates are here given, in the columns following the values of μ and μ', and in units of the fourth and third decimal places respectively. Subtracting these from the secular variations of the total annual variation (computed in accordance with Hill's formulas in the star tables of the *American Ephemeris*), gives the secular variation of the precession, which, again, is not the secular variation as ordinarily computed, but includes the effect of proper motion upon the computed precession of the star. By its use, the precessions for other dates should be correctly reproduced from the initial epoch, whenever terms of a higher order can be neglected.

My thanks are due to Captain F. V. McNair, Superintendent of the Naval Observatory, for his obliging and prompt transmission of star-positions taken from the unpublished catalogue of the zone-observations, by Gilliss, at Santiago; and also to Dr. B. A. Gould, and to Mr. H. M. Paul of the Naval Observatory, for transcripts of star-places from several catalogues not at my disposal. I embrace this opportunity to acknowledge my obligations to the Board of Directors of the Bache Fund of the National Academy of Sciences, for an appropriation, which has enabled me to employ a computer in the proper-motion researches upon which I am engaged.

List of Positions and Proper Motions for 1900.

Lacaille No.	Mag.	R.A. 1900.0	Prec.	Sec. Var.	Decl. 1900.0	Prec.	Sec. Var.	Proper Motion					
								μ	S.V. 0.0000	μ'	S.V. 0.000	P.M.	P.A
		h m s	s	s	′ ″	″	″	s		″			
75	6.8	0 19 47.46	+2.9273	—0.0322	—51 35 29.2	+19.977	—0.047	+0.049	— 6	—0.31	— 1	0.55	124.2
239	6.8	0 48 6.45	+2.9060	—0.0110	—30 54 3.6	+19.612	—0.097	+0.055?	— 3	+0.07?	— 2	0.71?	81.1
536	6.4	1 45 29.80	+2.5934	—0.0076	—38 54 23.6	+17.965	—0.176	—0.0049	+ 1	+0.320	0	0.325	349.90
1271	6.8	3 49 38.41	+2.5847	+0.0027	—23 25 30.0	+10.800	—0.327	+0.0231	— 3	—0.363	— 3	0.483	138.79
2437	6.5	6 41 38.56	+2.2614	+0.0010	—31 40 47.5	— 3.624	—0.319	—0.0143	— 1	—0.329	+ 2	0.376	209.02
2950	5.6	7 39 51.69	+1.8642	—0.0012	—41 55 9.9	— 8.463	—0.238	—0.001	— 7	—0.57	+ 2	0.57	181.1
3122	6.1	7 55 56.37	+1.0444	—0.0094	—60 2 7.5	— 9.716	—0.147	+0.076	+ 8	+0.07	— 9	0.57	83.0
4913	6.2	11 46 38.05	+3.0272	+0.0180	—30 16 13.2	—20.018	—0.017	—0.0033	+ 1	—0.284	0	0.287	188.56
5123	7.0	12 17 51.00	+3.3188	+0.0785	—67 5 4.7	—19.991	+0.044	—0.128	—27	+0.20	— 1	0.77	105.1
5319	6.5	12 49 24.39	+3.3451	+0.0370	—43 36 12.7	—19.588	+0.122	—0.019	— 2	—0.26	— 1	0.33	218.1
5437	5.9	13 8 3.57	+3.7128	+0.0706	—58 31 8.3	—19.171	+0.164	—0.035	— 1	—0.20	— 2	0.31	233.9
5892	6.3	14 13 20.24	+3.4210	+0.0218	—25 21 52.6	—16.753	+0.276	—0.030	— 2	+0.31	— 2	0.51	307.3
6273	6.5	15 7 37.94	+3.5265	+0.0203	—24 55 55.1	—13.698	+0.377	—0.0298	— 1	—0.058	— 3	0.109	261.86
Bb(5291)	7.9	15 15 40.64	+4.1745	+0.0118	—47 33 15.9	—13.176	+0.456	—0.036	0	—0.28	— 1	0.46	232.5
6521	6.5	15 40 59.50	+3.9186	+0.0282	—37 36 0.5	—11.430	+0.466	—0.0351	+ 1	—0.281	— 1	0.503	236.04
8267	6.6	19 55 32.96	+5.9098	—0.1026	—67 31 52.1	+ 9.687	+0.793	+0.161?	+10	—0.67	+22	1.15?	125.5
8525	7.2	20 34 27.01	+3.5479	—0.0155	—21 27 47.7	+12.511	+0.403	+0.0115	+ 1	—0.303	+ 2	0.362	146.83
8625	5.9	20 58 54.29	+6.2926	—0.2265	—73 33 53.7	+11.111	+0.667	+0.105	+ 1	—0.38	+11	0.59	130.5
8733	6.9	21 10 47.33	+1.7479	—0.0909	—61 15 32.2	+11.831	+0.116	+0.067	+ 2	—0.13	+ 5	0.64	132.1
8979	6.9	21 54 57.43	+1.0123	—0.0593	—53 33 35.5	+17.140	+0.296	—0.006	+ 4	—0.18	0	0.18	186.4
9037	5.3	22 1 17.28	+3.1933	—0.0258	—33 2 22.5	+17.550	+0.211	+0.0310	— 2	+0.007	+ 2	0.128	89.06
9076	5.7	22 11 42.49	+3.9135	—0.0607	—51 6 31.2	+17.855	+0.256	+0.050	0	—0.68	+ 3	0.81	147.11
9113	7.5	22 17 36.67	+3.3587	—0.0193	—26 20 12.1	+18.081	+0.208	+0.026	— 1	—0.16	+ 2	0.38	114.6
9112	5.7	22 18 17.91	+1.0018	—0.0731	—58 17 39.5	+18.110	+0.245	+0.0148	+ 1	—0.350	+ 1	0.369	161.56
9210	6.5	22 36 39.38	+3.5957	—0.0131	—47 13 28.5	+18.741	+0.179	—0.0011	+ 2	—0.318	0	0.318	182.00
9396	6.4	23 7 56.81	+3.6697	—0.0832	—63 13 55.6	+19.537	+0.116	+0.0724	— 9	—0.398	+ 2	0.631	129.11
9640	6.1	23 49 24.01	+3.1263	—0.0260	—40 51 26.6	+20.031	+0.013	+0.0334	— 3	+0.036	0	0.381	84.57

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* The declination of Lalande's Zone appears to require a correction of —30″.

Albany, January 1892.

ON THE SUPPOSED SECULAR VARIATION OF LATITUDES.

By S. C. Chandler.

I have read with some attention Prof. Comstock's two articles on the secular variation of latitudes, without being able to see that he establishes either the existence of the phenomenon or the nature of its relations to the periodical variation. I had hoped that some else would point out what appear to be weak points in the argument. [illegible]

to be said, the subject assuming importance for the reason that the alleged secular motion of the pole has been made the basis for a proposition to occupy stations about 110° east from Greenwich, for example, Peking, Nagasaki and Vladivostok. Such an operation, to successfully eliminate the 427-day periodic variation, would involve a protracted, possibly a continuous latitude-campaign. Before entering upon such an outlay of money and scientific effort, which can ill be spared, with the numerous important researches now pressing upon the attention of astronomers, it ought to be shown that the enterprise is likely to yield a fruitful result, which cannot be more economically reached by observations at existing observatories. I am sure that Prof. Comstock will agree to this, and will pardon the following outspoken expression of reasons why such expeditions as he suggests should not be ventured upon without deliberate caution.

To be brief as possible, I will not go into all the topics on which we fail to agree, but confine these remarks to the main point, the existence of a secular variation of the amount, and in the direction he indicates. Without beating about the bush, the evidence he adduces seems to me illusory.

We may pass lightly over the European observations, since they cannot affect the present discussion decisively, for obvious reasons. However, it should be said that, eliminating the effect of the 427-day variation from the Pulkowa latitudes from 1871–84, I get a value for 1882 greater by 0″.10 (*i.e.*, 18″.50) than that of Prof. Comstock, and an absolute constancy of latitude for this whole interval; also, that I have elsewhere shown (*H.C.O. Annals*, XVII, 137) that we are not by any means sure that the slight differences between Peters's, Gyldén's and Nyrén's results may not be due to personal equation entirely; and further, that there are other important data which might well have been included in the discussion. However, the very small observed differences in the latitudes of European observatories furnish no arguments on either side, as to the truth of Comstock's hypothesis. Coming to American observatories, then, it seems to me that he is neither just nor judicious in brushing aside so lightly the evidence of the Cambridge determinations, which flatly contradict his hypothesis. I recapitulate them here, including one by Prof. Rogers in 1864 with the prime-vertical transit, the approximate result of which he has communicated by letter, stating that the definitive value, which will shortly be published, can hardly differ by more than 0″.1 or 0″.2.

		° ′ ″
Bond-Peirce, prime-vertical,	1844–45	42 22 47.53
Gould, zenith-telescope,	1855	47.61
Rogers, prime-vertical,	1864	47.5
Small almucantar,	1883	47.63
Russian transit.	1883	47.45
Large almucantar,	1884–85	47.64

The hypothesis in question would imply an increase of latitude during the interval here comprised, of nearly two seconds (1″.79), but the observations show nothing of it. Comstock says that no conclusion can be drawn from these numbers until we know more about the relative errors. I do not see why, nor is it probable that astronomers generally will agree with him. The observers were competent, the methods were precise, the interval covered is more than six times that of the Madison circle-observations, and more than twice that of the Madison differential determinations. On the contrary, allowing the most extravagant assumptions as to possible error, this series alone seems to damage the hypothesis beyond repair.

As to Washington, Prof. Comstock dissents from Prof. Hall's mature opinion that there is no proof of secular variation at that observatory. I should be inclined, however, respectfully to defer to Prof. Hall's judgement in this matter, even if an independent examination had not led to the same result. While skepticism as to the trustworthiness of the transit-circle observations seems to be the fashion, there is one important piece of testimony that this discredit is ill-deserved, to a considerable extent.

In discussing the observations of *Polaris* with this instrument, 1866–85, I have been surprised to find that they reveal the existence of the 427-day periodical variation of latitude in a most unmistakeable and satisfactory manner. The series, treated in five groups, give the maxima and minima of the phenomenon with remarkable fidelity, as I hope to show in course of the regular series of articles on this subject, now in progress of publication. If it can be depended upon for this, it is certainly entitled to its weight on the question of the secular variation. Eliminating the effect of the periodical fluctuation, we find:

	″		″
1866.6	38.12	1878.1	37.45
1867.7	38.45	1879.3	38.24
1868.9	38.36	1880.4	37.43
1870.1	38.34	1881.6	38.47
1872.4	38.74	1882.8	37.84
1873.5	38.72	1883.9	37.95
1874.6	38.24	1885.1	37.55
1875.8	37.81	1886.3	38.15
1876.9	37.92	Mean	38.12

There is certainly no sign here of the increase of 0″.90, which the hypothesis would require during this interval.

As to the prime-vertical observations of *α Lyrae*, 1845–48, I get a latitude greater by 0″.3 or 0″.4 than Prof. Comstock's, from the same material. This may be due to the fact that I have eliminated the 427-day term by taking means of observations seven months apart. Thus we have, adding 0″.45, to refer to the parallel of the transit-circle,

	″
Using Gould's declination.	38.56
" Boss's "	38.37
" Auwers's "	38.10

This value, corresponding to the year 1847, ought by the hypothesis to be one and a third seconds smaller than the above mean for 1876, but it is actually slightly larger. However, this argument is entitled to but little weight. The observations were made by MAURY and another naval lieutenant. It was during this very period that the former boasted, in a letter, dated 1847 January 1, that "he had never seen an instrument of the kind before, and had no one with him who had." The prime-vertical observations in 1882–84, also, were not made by the astronomers of the observatory, but by naval officers.

The observations at Melbourne (see this Journal, no. 250, p. 75) contradict the hypothesis in question in an equally emphatic manner. Situated 146° from the 69th meridian, there ought here to be an increase of the southerly latitude by 0″.037 annually, or about three-quarters of a second from 1863 to 1881, but there is not a vestige of it in the following table, where the 127-day term has been eliminated.

	″		″
1864.2	53.17	1873.4	53.51
1865.3	53.09	1874.6	53.33
1866.5	53.31	1875.8	53.38
1867.6	53.02	1876.9	53.61
1868.8	53.48	1878.1	53.10
1870.0	53.31	1879.1	53.59
1871.1	53.31	1883.6	53.39
1872.3	53.80	Mean	53.41

It appears, then, that the presumed secular variation must depend entirely upon only seven years' observations with the meridian-circle, and five zenith-telescope determinations, at the Madison Observatory. This is not a very wide basis on which to rest so important a proposition. A hypothetical correction dependent on the sun's longitude, such as Prof. COMSTOCK has employed, seems to me as likely to introduce, as to eliminate, error. It certainly does not eliminate the effect of the 127-day term. I desire further to point out that, from the commensurability of the latter term with the year, there ought to appear, in every series of yearly means of latitude-results, an apparent period of seven years. It is curious that the Madison series fail to exhibit this phenomenon, and that they are the only good series of the observations yet scrutinized, in which it fails to be manifest. Probably Prof. COMSTOCK, with the full data under his eye, will be able to furnish the explanation.

There are other interesting points on which I would like to say a few words, but this communication is already too long.

In conclusion, while it is possible that in course of time an actual secular variation of latitude may be demonstrated, I cannot see that there is at present any manifestation of its existence, either in amount or direction, which can guide us in formulating plans for expeditions; and so far as existing observations are concerned, it is premature to speculate upon its character until the laws of the periodic variation are more fully understood.

Cambridge, 1892 *January* 24.

OBSERVATIONS OF VARIABLE STARS AT THE OBSERVATORY IN UPSALA.

By N. C. DUNÉR.

At my arrival in Upsala, 1889, I found the observatory provided with an old refractor, with a good object-glass of 245 mm., by Steinheil, but mounted in a manner which made it quite unfit for all modern astronomical work. Beside this instrument, and a moderate-sized meridian instrument, there was a refractor, by Troughton and Simms, with object-glass of 100 mm. The mounting of this instrument being in good order, I resolved to use it for observations of variable stars. Some experiments, however, proved that the telescope of this instrument was not powerful enough for more thorough observations of this kind, and, thus, I ordered from Messrs. REINFELDER & HERTEL, in Munich, a comet-seeker, with an object-glass of 162 mm., and a focal length of 116 cm. This instrument arrived in the first days of October, 1890, and was the same day mounted on the parallactic stand of the Troughton refractor. This telescope has proved to be a very fine one, and I have since that time observed all the variable stars between the north pole and the thirtieth degree of north declination, and all the stars of the *Algol*-type, which can be observed here; also beside these some other stars, which seemed to me particularly interesting. These observations will be continued to the end of this year, when I shall have got a new astro-photographic refractor with object-glasses of 36 and 33cm., respectively. My observations have already led to the determination of a number of maxima and minima of stars, and it is my intention to publish, from time to time, the results in this Journal.

To-day, I communicate the following:

1. *U Cassiopeæ.*

In 1890, this star was observed 9 times, between October 26 and December 30, after which date it vanished; and 21 times in 1891, from August 1 to October 7, when I glimpsed it for the last time. In neither of these years, have I determined a maximum epoch, the star being already slowly decreasing at the first observation in each. The comparison of the light-curves show, however, that the period is nearly 280 days, and that the next maximum will arrive in April, 1892.

2. *S Cassiopeæ.*

The observations in 1891 of this star began somewhat late, and continued from August 4 to November 7. The 26 observations give:

Max. 1891 Aug. 9. Mag. 7.8

The maximum may have arrived several days before this epoch.

3. *R Arietis.*

Twenty-five observations, from August 9 to November 7, give, with considerable certainty,

Max. = 1891 Sept. 22. Mag. = 8.0

4. *R Ceti.*

In 1890–1, this star was observed 12 times from November 20 to January 10, and in 1891, 17 times, between September 21 and December 21. The following epochs of maximum were deduced:

1890 Dec. 10: Mag. = 7.9
1891 Nov. 6; Mag. = 7.9

The first epoch is well determined; the second maximum may have arrived some days later, no observation being possible from November 7 to December 4.

5. *R Tauri.*

Eight observations, from October 7 to November 20, give with considerable uncertainty,

Max. = 1890 Oct. 21; Mag. = 8.6

6. *U Geminorum.*

I have been particularly favored by success in my observations of this wonderful variable, having been able to observe two maxima in this year, both with observations in the ascending part of the light-curve. These observations fully confirm the already supposed enormous velocity with which this star rises to its maximum of brightness, the time between the commencement of increase and the maximum being 36 to 60 hours only.

1st Maximum. On the 6 January, 1891, at a temperature of −26°, I saw, at 5^h 20^m, sidereal time, *U* in the brightness

d 3 *U* 2 *b*

[*d* and *b* are comparison stars, proposed by Winnecke, *A.N.*, No. 1120.] The low temperature prevented further observations on this night. Already on the 7th, the star was almost at maximum. Unfortunately, I was after the 11th instant, prevented by illness from continuing these observations. At my request, Dr. Charlier observed the star, but only on two nights, the 12th and the 19th, and in the second observation he did not strictly follow the method of Argelander. This observation is consequently not rigorously comparable with the others. The resulting brightnesses of the star, in steps, are

Jan.	6.5	*U* =	3.2
	7.2		26.6
	7.5		29.5
	8.		32.5
	9.		30.5
	10.		29.
	12		29.
	19.		26.5

These observations give

Max. = 1891 Jan. 8.3 Mag. = 9.0

and perhaps a secondary maximum about January 15. The variation began January 5.8.

2d Maximum. On the 31 October at $3^h.5$, sidereal time, I found

d 3 *U* 5 *b*

and have since obtained the following observations:

Oct.	31.53	*U* =	5.0
	.57		6.0
	.62		8.0
	.67		9.1
Nov.	1.16		27.3
	.54		29.0
	2.54		27.8
	4.53		20.0
	5.46		15.0
	7.50		1.0

Thus we have:

Max. = Nov. 1.7 Mag. = 9.2

The variation began Oct. 31^d 1^h M.T. at Upsala.
The variation ended Nov. 8^d 4^h M.T. at Upsala.

The character of the variations in these two cases is quite different. The duration of the first was great, probably attaining almost the maximum duration indicated by Schönfeld. The second was one of the shortest hitherto observed, perhaps the shortest of all. Both agree in confirming the extraordinary rapidity with which the star rises to its maximum brightness; the hourly increase having been at least one step, or the tenth of a magnitude. The observations on October 31, show that this increase is uniform, and not of an explosive character, as we might almost be inclined to suppose.

7. *R Aquilae.*

I have observed this star 26 times between 1890 October 5 and 1891 January 10, and 48 times between 1891 August 7 and December 12. The results are

Max. = 1890 Nov. 17; Mag. = 7.0
Max. = 1891 Oct. 8; Mag. = 5.9

In spite of the great number of observations, the first epoch is by no means very certain, because cloudy weather prevented all observations in the first twenty days of November. Moreover, the only two observations which could be obtained in November disagree with the others. The maximum in 1891, on the contrary, seems to be as well determined as possible. The difference of magnitude in the two years was very marked.

8. *Z Cygni.*

Fourteen observations were obtained between 1890 October 15 and 1891 January 5, and 36 from 1891 August 4 to November 7. In both years, the observations of this star

began later than desirable, and consequently the following maxima are very uncertain. They are

Max. = 1890 Nov. 2 ; Mag. = 8.5
Max. = 1891 Aug. 8 ; Mag. = 8.1

If these epochs were correct, the period is 279 days, and the next maximum will arrive 1892 May 13.

9. *X Cygni.*

In 1890, I determined 4 maxima and 2 minima of this star, and in 1891, 6 maxima and 7 minima, viz. :

MAXIMA.

	Date	Mag.	Obs.	O—C
1890	Oct. 24.0	6.3	10	—0.06
	Nov. 26.5 ??	6.3	1	+0.64
	Dec. 12.0 ?	6.3	5	—0.26
	Dec. 29.0	6.2	5	+0.34
1891	Aug. 15.5	6.3	5	+0.24
	Aug. 31.4	6.3	1	—0.26
	Sept. 17.0	6.2	6	—0.06
	Oct. 3.8	6.3	7	+0.34
	Oct. 19.3	6.3	4	—0.56
	Nov. 5.6	6.3	6	+0.34

MINIMA.

	Date	Mag.	Obs.	O—C
1890	Nov. 21.2 ?	7.5	2	+0.84
	Dec. 6.1	7.9	4	—0.36
1891	Jan. 8.1	7.4	5	—0.16
	Aug. 11.2	7.5	5	+1.44
	26.9	7.5	4	+0.74
	Sept. 11.1	7.5	6	—0.16
	27.7	7.5	7	—0.26
	Oct. 13.6	7.5	3	—0.74
	30.7	7.5	4	—0.06

The observed maxima give the following formula

$$\text{Max.} = 1891 \text{ Sept. } 17.06 + 16^{d}.40 \,.\, E$$

The second and the third maximum, and the first minimum in 1890, are uncertain: all the dates in 1891 are, on the contrary, well determined. The minima arrive $5^{d}.5$ before the maxima. The residual errors are given under the heads of O—C. The fact, pointed out by Mr. Chandler, viz., that "bright and faint minima alternate, but not regularly," is shown in my observations by the faint minimum in December, 1890. In 1891, all the observed minima were certainly bright. At this time no faint minima occurred.

10. *R Vulpeculae*

Eleven observations between October 11 and November 20, 1891, give

Max. = 1890 Oct. 19 ; Mag. = 8.0

The observations began somewhat too late for obtaining a quite trustworthy determination of the maximum epoch.

Upsala, 1891 *December* 31.

NEW ELEMENTS AND EPHEMERIS OF COMET *e* 1891 (*BARNARD, Oct. 2*).

By W. W. CAMPBELL.

By basing Mr. Barnard's observations of Oct. 3, 6 and 9 upon Cordoba comparison-stars (*Gen. Catal.* 9952, *Zone Catal.* VII, 4080, and *Zone Catal.* VIII, 1196), we obtain the following apparent places of this comet:

Mt. Hamilton M.T.	App. α	App. δ
1891 Oct. $3^{d}\ 16^{h}\ 7^{m}\ 50^{s}$	$7^{h}\ 27^{m}\ 0^{s}.42$	$-29^\circ\ 17'\ 3''.5$
6 16 15 19	7 55 20.83	—33 36 41.3
9 16 16 5	8 15 15.81	—37 11 43.2

From these I have computed the elements and ephemeris given below. The residuals for the middle place are large, but cannot be reduced on the hypothesis of parabolic motion. A study of the residuals furnished by the eight published observations shows that the observed places will be much better represented by an orbit deviating slightly from a parabola. But the very few observations at hand were made under unfavorable circumstances, and cover only a short portion of the orbit; so that further discussion is not justified until more observations are secured. It is hoped that the ephemeris will assist in the rediscovery of the comet.

Elements.

$$T = \text{Gr. M.T. } 1891 \text{ Nov. } 12^{d}.93289$$

$$\left.\begin{aligned}\omega &= 268^\circ\ 36'\ 20''.7\\ \Omega &= 217\ \ 39\ \ 58.7\\ i &= 77\ \ 41\ \ \ 3.1\end{aligned}\right\}1891.0$$

$$\log q = 9.989611$$

$$T = \text{Gr. M.T. } 1891 \text{ Nov. } 12^{d}.93289$$

$$\left.\begin{aligned}\omega &= 268^\circ\ 36'\ 20''.1\\ \Omega &= 217\ \ 40\ \ 19.0\\ i &= 77\ \ 44\ \ \ 2.8\end{aligned}\right\}1892.0$$

$$\log q = 9.989611$$

Residuals for the Middle Place (Obs.—Comp.).

$$\cos\beta'\ \Delta\lambda' = -13''.3, \qquad \Delta\beta' = -6''.0$$

Constants for the Equator, 1891.0.

$$x = [9.901259]\, r \sin(187^\circ\ 55'\ \ 9''.3)$$
$$y = [9.892119]\, r \sin(131\ \ 30\ \ 28\ .8)$$
$$z = [9.936731]\, r \sin(252\ \ 15\ \ 54\ .8)$$

Constants for the Equator, 1892.0

$$x = [9.901183]\, r \sin(187^\circ\ 55'\ 25''.9)$$
$$y = [9.892477]\, r \sin(131\ \ 31\ \ \ 7\ .5)$$
$$z = [9.936746]\, r \sin(252\ \ 15\ \ 37\ .7)$$

Ephemeris for Greenwich Mean Time.

1892	App. α h m s	App. δ ° '	log r	log Δ	Br.
Jan. 20	16 9 5	−36 16.9	0.1764	0.2639	0.17
22	11 4	35 39.3			
24	12 56	35 1.5	0.1899	0.2621	0.16
26	14 39	34 23.3			
28	16 14	33 44.7	0.2031	0.2596	0.15
30	17 41	33 5.8			
Feb. 1	19 0	32 26.3	0.2160	0.2563	0.15
3	20 10	31 46.4			
5	21 12	31 5.9	0.2286	0.2525	0.14
7	22 5	30 24.8			
9	22 50	29 43.1	0.2410	0.2484	0.14
11	16 23 26	−29 0.7			
Feb. 13	16 23 54	−28 17.6	0.2530	0.2432	0.13
15	24 13	27 33.7			
17	24 23	26 49.0	0.2648	0.2380	0.13
19	24 24	26 3.4			
21	24 18	25 16.9	0.2762	0.2325	0.12
23	24 1	24 29.5			
25	23 36	23 41.2	0.2874	0.2268	0.12
27	23 1	22 51.8			
29	16 22 16	−22 1.4	0.2983	0.2211	0.12

Mt. Hamilton, 1892 *January* 12.

My preliminary orbit, published in the *Science Observer* No. 96, was computed from the observations of October 2, 3 and 4, as they are printed in the *Publications Astronomical Society of the Pacific*, Vol. III, p. 378.

NEW ASTEROID.

A planet of the eleventh magnitude was discovered photographically at Heidelberg Nov. 28. It has been observed at Vienna as follows:

1892 Jan. 20.2494 Greenw. M.T. $\alpha = 3^h\ 50^m\ 6^s.1$, $\delta = +22^\circ\ 17'\ 34''$. Daily motion, $+ 12^s$ in α, and $2'$ northward.

Mr. Charlois has assigned names, as follows, to asteroids recently discovered by him: —

305, *Gordonia*; 307, *Nike*.

JOHN COUCH ADAMS.

The telegraph brought tidings, on January 22, of the death of this eminent mathematician and astronomer, in his seventy-second year, after a protracted illness.

He was born, 1819 June 5, at Laneast, a village near Launceston, in Cornwall, England. In 1843, he graduated at Cambridge, with the highest honors, and soon afterwards undertook the investigation of the perturbations of *Uranus*, and of the position of the supposed disturbing planet, which soon brought him high distinction. The history of these computations, of the contemporaneous, yet very diverse, ones by LeVerrier, and of the discovery of the disturbing body, forms one of the most curious and interesting chapters in the history of modern astronomy.

After residing in Cambridge for some years as a Fellow of St. John's College, and also serving for a short time as Professor at the University of St. Andrew's, Mr. Adams was recalled to Cambridge in 1858, as successor to Dr. Peacock. Subsequently he became the successor of Prof. Challis at the Cambridge Observatory, where he has since remained.

His researches in planetary and lunar astronomy were of high value, especially those pertaining to the secular variations of the elements of the Moon's orbit. His Note on the Constant Term in the reciprocal of the Moon's Radius Vector, published in 1878, disclosed a singular property in this term, which he demonstrated with peculiar elegance.

Prof. Adams's astronomical activity was continued until terminated by his failing health. His latest communication to the Royal Astronomical Society was published in 1890, in The Appendix to vol. L of the *Monthly Notices*.

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CONTRIBUTIONS TO THE KNOWLEDGE OF THE VARIABLE STARS.

By S. C. CHANDLER.

VI.

In the series of papers with the above title, here slightly abridged, and the collateral series dealing especially with the stars of the *Algol*-type, the existence of inequalities in the periods of a large number of variables has been pointed out, and their numerical laws determined. I have on hand the manuscript, nearly ready for the printer, of some others, which are held back to incorporate additional observations. In addition, similar inequalities have been detected in many other cases, partially enumerated in the preface to the first *Catalogue of Variable Stars*. These will be subjected to calculation as soon as the data suffice.

Meanwhile some researches have been made as to the causes of these heretofore mysterious phenomena, the results of which seem to possess interest enough to communicate.

1090. *β Persei.*

The inequalities in the period of this star, and also some other phenomena whose existence is demonstrated later in this paper, are satisfactorily accounted for by the following theory.

Algol, together with the close companion, — whose revolution in $2^d\ 20^h\ 8$ produces by eclipse the observed fluctuations in light, according to the well-known hypothesis of GOODRICKE, confirmed by the elegant investigation of VOGEL, — is subject to still another orbital motion, of a quite different kind. Both have a common revolution about a third body, a large, distant and dark companion or primary, in a period of about one hundred and thirty years. The size of this orbit around the common center of gravity is about equal to that of *Uranus* around the sun. The plane of the orbit is inclined about 20° to our line of vision. *Algol* transited the plane passing through the center of gravity perpendicular to this line of vision, in 1804 going outwards, and in 1869 coming inwards. Calling the first point the ascending node, its position-angle, reckoned in the ordinary way, is about 65°. The orbit is sensibly circular, or of very moderate eccentricity. The longest diameter of the projected ellipse, measured on the face of the sky, is about $2''.7$. A necessary consequence of this theory is an irregularity of proper motion with an amplitude of something over a fifth of a time-second in right-ascension and nearly one and a half seconds in declination;* the middle point being the center of gravity of *Algol* and the distant unknown companion, and the uniform proper motion of the latter being $-0^s.0010$ and $+0''.0120$ annually, in the two coordinates, respectively. The annual parallax of the star is about $0''.07$. The mean period of light-variation is $2^d\ 20^h\ 48^m\ 56^s.00$, and the principal epoch of minimum, from which E is counted, is 1800 Jan. $1^d\ 18^h\ 22^m.0$, Greenwich M.T.

The proof of the above propositions rests, in the first line, upon the inequalities in the period of *Algol*, which I have already fully investigated, *A.J.* VII, pp. 165–183; in the second, upon the irregularity in its proper motion, which I shall now try to demonstrate. Notwithstanding the extreme delicacy of the problem, the evidence of such an irregularity seems to me to be satisfactory, but if, as may easily be, there still remains reasonable doubt about it in conservative minds, I beg it to be observed that such doubts can affect merely the particular numerical results, and not the tenability of the hypothesis itself; since it may be shown, by a strong inductive train of reasoning, irrespective of any recognizable irregularity in proper motion, that the observed disturbances in the times of minima, whose existence and character are as well substantiated as any fact in astronomy can be, require for their explanation a perturbation by a third body situated, with reference to the other two, according to some such general relations as are outlined in the above theory. The function that an actual irregularity of motion performs, if admitted, is to furnish extremely valuable corroborative proof on the one hand, while on the other

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* This is my reason for rejecting the star in the latitude-results for Cambridge, *A.J.*, no. 254, p. 108.

it enables us to ascertain the numerical values of some of the elements which would be indeterminate from the variations of the period alone.

As the distant companion or primary, whose existence is thus theoretically indicated, may have enough intrinsic or reflected light to be visible in our large object-glasses, it is worth while to state here where it is to be looked for. According to the orbit hereafter given, the present position-angle of the unknown body from *Algol* is 32°, and its distance is $0''.71\left(1+\frac{1}{m}\right)$, where m is the unknown mass, the combined mass of *Algol* and its close companion being taken as unity. Thus, if $m = 3$, the distance will be about 1″; if $m = 0.08$, the distance will be 10″, and so on. Only rude guesses can be made as to the probable brightness; but, with reasonable assumptions as to albedo, if the unknown body has no light of its own and is only equal to *Algol* in size, it cannot be far from the reach of the best telescopes; if it is larger than *Algol*, or is partly luminous, the chances of seeing it under favorable conditions are enough to warrant an earnest effort to do so.

Let us first take up the examination of the character of the proper motion. For this purpose the systematic errors of the catalogue-places have been eliminated by treating the places differentially, taking the relative differences between *Algol* and thirteen of the Pulkowa *Hauptsterne* situated, in general, within ten degrees of the former in declination, and within one hour in right-ascension; the stars being so selected that *Algol* occupies nearly the center of the region. These comparison-stars are; *θ, γ, ρ, α, δ, ν, ζ, ε, ξ*, in *Perseus*; and *β Trianguli*, *γ Andromedae*, 41 *Arietis*.

If all the comparison-stars were contained in every catalogue used in the discussion, the deduced irregularities in the proper motion of *Algol* would not only be free from their systematic errors, but also from the errors of the places and motions of the standard system used as the medium of comparison, provided only that those motions were uniform. But, since this would materially limit the number of the comparison-stars available, it was thought best, at least in this preliminary discussion, not to adhere rigorously to the method in this respect, but to use all of the above stars found in each catalogue, in determining the correction to be applied to *Algol's* place. The method did not require that the selection of the catalogues should be limited to those containing absolute places. This will suffice for general description of the process; more particular explanations will follow in their appropriate connection.

Algol :— RIGHT-ASCENSION.

Authority	Epoch	Eq.	Obs.	Cat. R.A.	Corr'n	Corr $d\alpha$ 1875.0	Wt.	$\alpha - \alpha_0$	
								O	*C*
				m s	″	s		s	s
Bradley	1753.9	1755	9	52 19.71	0.00	2.64	2	--0.051	—0.067
d'Agelet	1784	1800	6	55 12.47	+ .30	2.70	1	+ .039	+ .074
Piazzi	1804.5	1800	28	12.9	+ .17	3.00	4	+ .360	+ .105
Groombridge	1810	1810	3	51.17	+ .32	2.88	1	+ .245	+ .097
Struve	1824	1830	7	57 8.32	+ .07	2.59	5	— .031	+ .047
Pond	1831	1830	8	8.25	+ .07	2.52	5	— .094	+ .012
Cambr. (Airy)	1834	1830	4	8.26	+ .09	2.55	3	— .061	— .029
Rümker	1836	1836	3	31.74	+ .01	2.75	1	+ .141	— .015
Radcliffe	1845.2	1845	5	58 6.22	+ .07	2.50	4	— .100	— .057
Paris I	1845.9	1845	138	6.26	+ .08	2.55	10	— .049	— .059
Greenwich	1846	1845	3	6.21	+ .07	2.49	3	— .109	— .059
Pulkowa	1847	1845	41	6.26	+ .05	2.52	9	— .078	— .061
Greenwich	1850.8	1850	7	25.55	+ .09	2.50	4	— .094	— .078
Radcliffe	1857.1	1860	5	59 4.28	+ .05	2.47	4	— .118	— .095
Greenwich	1859.9	1860	3	4.27	+ .02	2.43	4	— .155	— .102
Paris II	1860.8	1860	170	4.31	+ .06	2.51	10	— .074	— .103
Greenwich	1864.4	1864	12	19.81	+ .05	2.51	7	— .071	— .106
Pulkowa	1865	1875	–	60 2.50	.00	2.50	10	— .080	— .107
Bonn	1866	1866	8	59 27.59	+ .03	2.52	6	— .059	— .106
Leipzig	1867	1866	9	27.57	— .03	2.44	7	— .138	— .106
Greenwich	1872.7	1872	5	50.82	+ .04	2.50	5	— .072	— .101
Paris III	1871.5	1875	36	60 2.42	+ .03	2.45	10	— .121	— .098
Rogers	1874.8	1875	53	2.49	+ .01	2.50	10	— .070	— .097
Pulkowa	1876.4	1875	22	2.52	— .02	2.50	9	— .069	— .096
Greenwich	1880.6	1880	6	21.85	+ .02	2.47	6	— .094	— .082
Paris (82–83)	1883	1883	16	33.48	+ .03*	2.47	7	— .092	— .070
Washington (84–86)	1885.5	1885	7	60 41.33	—0.03	2.49	6	—0.070	—0.065

Algol: — Declination.

Authority	Epoch	Eq.	Obs.	Cat. Decl.	Corr'n	Corr'd δ 1875.0	Wt.	I	II	δ — Δ O	δ — Δ C
				′	″	″		″			
Bradley	1754.1	1755	4	59 29.0	0.00	19.17	1	—1.13	—3.44	—0.44	—0.69
d'Agelet	1784	1800	6	10 28.6	—2.93	20.32	½	—0.21	—1.76	+ .35	— .02
Piazzi	1803	1800	6	10 27.0	—1.35	20.30	1	— .42	—1.41	+ .10	+ .54
Groombridge	1810	1810	15	12 51.56	—0.52	21.11	3	+ .33	—0.50	+ .83	+ .66
Bessel	1821	1820	13	15 15.10	— .64	20.64	10	— .23	— .78	+ .23	+ .68
Struve	1821	1830	7	17 38.72	— .40	20.41	5	— .49	— .98	—0.01	+ .66
Pond	1831	1830	12	40.8	— .99	21.90	6	+ .94	+ .67	+1.37	+ .55
Cambr. (Airy)	1834	1839	2	40.28	— .84	21.53	2	+0.55	+0.35	+0.96	+ .48
Rümker	1836	1836	3	19 2.33	— .41	[17.92]	0	[—3.08]	[—3.22]	[—2.67]	+ .45
Cambr. (Challis)	1837	1837	11	19.62	— .85	20.41	6	—0.57	—0.68	—0.16	+ .40
" "	1838	1838	6	34.79	— .85	21.28	4	+ .26	+ .17	+ .66	+ .37
" "	1840	1840	10	20 3.13	— .85	20.98	5	— .05	— .09	+ .31	+ .32
Greenwich	1840	1840	10	2.45	— .35	20.80	5	— .23	— .27	+ .16	+ .32
Edinburgh (41–42)	1842.5	1842	7	31.75	— .80*	21.02	4	— .03	.00	+ .35	+ .26
Radcliffe	1845.5	1845	4	21 13.8	— .40	20.56	3	— .51	— .41	—0.15	+ .16
Bond-Peirce	1845	1845	40	11.81	.00	21.97	9	— .11	+ .99	+1.27	+ .16
Paris I	1846.5	1845	428	13.1	+ .09	20.35	10	— .71	—0.60	—0.37	+ .12
Greenwich	1846	1845	3	14.84	.00	22.00	3	+ .92	+1.01	+1.29	+ .13
Pulkowa	1845	1845	2	13.58	+ .05	20.79	2	— .29	—0.19	+0.09	+ .16
Greenwich	1851	1850	4	22 25.31	—0.19	20.84	3	— .28	— .03	+0.07	— .01
Cambridge	1851	1851	2	41.55	—1.20*	21.78	2	— .34	+0.91	+1.01	— .04
Radcliffe	1859.2	1860	4	21 47.00	—0.47	19.65	3	— .55	—1.07	—1.22	— .30
Greenwich	1859.9	1860	3	17.38	— .06	20.44	3	— .76	—0.27	—0.44	— .32
Brussels	1862	1862	1	25 15.7	— .20*	20.15	1	—0.59	— .04	— .28	— .36
Paris II	1862.2	1860	84	24 17.5	+ .01	20.63	10	—1.11	— .50	— .81	— .45
Greenwich	1864.6	1861	11	25 44.01	— .08	20.13	7	—1.07	— .52	— .75	— .38
Pulkowa	1865	1875	–	28 20.21	.00	20.21	10	—1.03	— .41	— .73	— .46
Bonn	1866	1866	8	26 13.71	— .15	21.35	6	+0.10	+ .75	+ .40	— .18
Leipzig	1867	1866	9	12.78	— .50	20.04	7	—1.22	— .54	— .92	— .51
Leiden	1869.6	1870	16	27 9.82	— .32	20.44	8	—0.85	— .10	— .55	— .56
Greenwich	1872.7	1872	10	38.63	— .69	20.49	7	—0.82	+ .01	— .54	— .62
Paris III	1874.7	1875	39	28 20.7	— .43	20.27	10	—1.06	— .18	— .79	— .65
Rogers	1874.8	1875	19	20.20	.00	20.20	10	—1.13	— .24	— .86	— .65
Pulkowa	1876.1	1875	19	20.3	+ .19	20.19	9	—0.85	+ .07	— .58	— .66
Greenwich	1879.5	1880	13	29 31.82	— .10	20.88	8	—0.19	+ .52	— .23	— .69
Paris (82–83)	1883	1883	18	30 14.08	— .40*	20.38	8	—1.02	+ .08	— .78	— .69
Washington (82–86)	1885.5	1885	6	30 41.85	+0.10	20.37	6	—1.05	+0.12	—0.82	—0.69

The above tables contain the data used in discussing the proper motion. The first five columns need no remark. The sixth, headed "Correction," is the mean value, for the several stars and catalogues, in the table given at the end of this article. This latter table was formed by taking the differences, C—O, between the catalogue-places and Auwers's *Fundamental-Catalog* reduced to the date, assigning weights as follows:

Obs.	Wt.	Obs.	Wt.
1	1	12–17	6
2	2	18–25	7
3–4	3	26–35	8
5–7	4	36–50	9
8–11	5	over 50	10

For a few authorities, indicated above by an asterisk, the table does not contain the data for the corrections; which, however, were assigned on the same principles as in the other cases.

The seventh column gives the observed place, so corrected reduced to 1875.0, without applying proper motion. The weights in the eighth column were found by multiplying the catalogue-weights, presently given, by the number of observations, and entering the table just given with the product. These catalogue-weights are: for catalogues since 1860 generally (2), except Paris 1875 (1½); for catalogues before 1860 generally (1), except Struve and Bessel (1½), Rümker, Groombridge, Piazzi and Auwers's Bradley, (½); and d'Agelet (¼).

The ninth and tenth columns of the table of declinations are added to bring out perspicuously the fact that the assumption of uniform proper motion is incompatible with the observations. The first, (I), is a comparison with the values 10° 28′ 21″.33 + 0″.0085 (t—1875), which satisfy the data early in this century tolerably well, but leave negative deviations of a second in all the more modern ones and also in Bradley's time. The second, (II), is a comparison with

the values 40° 28′ 20″.11 − 0″.0180 (t − 1875), found from a least-square solution of the data since 1840, and displays evidence of system in the deviations, even in the group from which it was derived, and egregious discordances in the earlier observations, also of a progressive kind. Indeed, whatever way the facts are examined, we find a marked change of sign in the proper motion in declination near the middle of the century; also an inequality in the right-ascension near the beginning of the century, which cannot be accounted for by errors of observations.

The last two columns will be better understood later in the article, but it may be well to state here that O is the deviation of the observations from the uniform proper motion hereafter deduced for the center of gravity of the system, and C is the corresponding representation by the provisional orbit of *Algol* around this center, which results from the variations of the times of the light-minima and the deviations of the star's place from uniform motion.

Owing to want of room in this number, the remainder of Dr. CHANDLER's communication is delayed until the next. — G.

"ON THE SUPPOSED SECULAR VARIATION OF LATITUDES." A REPLY TO MR. S. C. CHANDLER.

BY GEORGE C. COMSTOCK.

The article by Mr. S. C. CHANDLER, in no. 251 of this Journal, bearing the above title, calls for reply from me; which I shall here present as briefly as possible, since the details of my investigation so far as they relate to American observations are soon to be published elsewhere. Passing over those matters of difference, which though included in his paper, Mr. CHANDLER himself designates as immaterial, I take up first the

Cambridge Observations. Mr. CHANDLER includes in his table of Cambridge latitudes one result to which I have not hitherto had access, the ROGERS determination of 1864, although I have made direct application to Prof. ROGERS and to the Director of the Harvard College Observatory, neither of whom were able to furnish it to me. This determination, being made by transits over the prime vertical, may be assumed comparable with the BOND-PEIRCE determination of 1845, and deserves to be taken into account; but I must still maintain that no proper comparison can be made between the almucantar, zenith-telescope and prime-vertical work.

I infer from the tone of Mr. CHANDLER's paper that he has considered this opinion as in some way derogatory to the capacity and skill of the observers, and I take this occasion for disclaiming any such intention and of saying, what it did not then appear necessary to say, that latitude-results obtained by experienced observers, using good instruments and approved methods, will frequently show most surprising discrepancies when the results of different methods are compared. Thus to cite a recent instance, I select from the volume of *Astronomisch-Geodätische Arbeiten I. Ordnung* published by the Royal Prussian Geodetic Institute in 1889, p. 235, the following determinations of the latitude of Kiel:

	°	′	″	″	1887
From zenith-distances,	54	20	28.71	± 0.05	July 12–28
" prime-vertical,			28.18	± 0.04	Aug. 1–18
" Horrebow (Talcott) method			27.65	± 0.05	" 23–Sep. 21

These apparently excellent results differ among themselves by more than twenty times their probable errors, and the experience furnished by the Prussian geodetic work indicates that systematic differences between the results furnished by different methods are to be regarded as the rule rather than the exception, [see p. 155 of the volume cited.] I infer that such systematic differences may as well exist among American as among European observations, and that neither variation nor permanence of latitude can be shown from the heterogeneous Cambridge data, however small their probable errors may be.

It will not escape notice that, among other points at which my numerical results differ from those of Mr. CHANDLER, is the latitude of Cambridge furnished by the BOND-PEIRCE work of 1844–45. I have not been able to give this work a thorough revision; but I have endeavored to eliminate from it the effect of some errors which seem to have escaped Mr. CHANDLER's notice in his treatment of it (*Annals H.C.O. Vol. XVII*). PEIRCE, in his discussion of the observations, neglects the azimuth of the instrument until the close of his paper, where he shows that it amounted to 37″ and that the correction due to this deviation is insensible. This is true for results depending upon transits over both verticals, but it is not true of results derived from east or west observations only. A considerable number of such cases occur in the work, and I am unable to find that any correction for azimuth has been applied to them, although I have not duplicated the computations to determine whether such a correction has been introduced without specific note being made of the fact. These incomplete observations I have provisionally excluded from the final result. A more serious source of difference between Mr. CHANDLER's result and mine lies in the treatment of the observations of β *Persei* which he rejects because discordant. I have discussed the declinations of β *Persei* and γ^1*Andromedae*, making use of authorities ranging from AUWERS's BRADLEY to the Ten-Year Catalogue and Madison observations of 1885, with the following results for the epoch 1845.0, referred to AUWERS's declination-system:

	° ′ ″
β Persei,	40 21 13.50 ± 0.10
γ′ Andromedae,	41 34 57.65 ± 0.09

Using **Auwers**'s declinations of the other stars, and employing only transits over both verticals, I obtain the following latitude results:

Star	Obs.	φ″	Weight
α Lyrae,	4	47.65	4
β Persei,	5	46.62	4
γ′ Andromedae,	9	48.02	6
μ Urs. Maj.,	6	47.61	4
8 *Can. Ven.*,	3	47.05	3

Adopted	47.47	± 0″.19
Reduction to dome,	— 0.47	
Latitude of dome,	47.00	1845.0
" (Rogers),	47.5	1861
Annual variation of φ,	+0″.03	± 0″.013

Since Mr. **Chandler** states that **Rogers**'s result, as he prints it, can hardly differ from the definitive value by more than 0″.1 or 0″.2, I adopt 0″.15 as the probable error of the provisional result with which the p.e. of the annual variation has been computed. The Cambridge observations therefore indicate a secular variation of latitude which agrees substantially with that observed at Madison and Washington. This conclusion will not be sensibly modified by adopting Mr. **Chandler**'s own discussion of the observations of 1845, if his result from *β Persei* is retained.

Washington Observations. It does not appear profitable to spend much time upon a discussion of the results furnished by the Washington transit-circle. Upon Mr. **Chandler**'s own showing, he has been unable to so adjust them as to bring the maximum discrepancy between the adopted mean results for consecutive years below a second of arc. This points plainly to the presence in the data of undetermined sources of systematic error and it has been elsewhere shown that these systematic errors are fairly constant for a year but change *per saltum* when the instrument is reversed. That the observations furnish indications of a periodic variation of latitude, not differing much from a year in length, can therefore furnish no assurance that the mean results of different years are comparable. A discussion of these sources of systematic error is contained in a recent paper by Prof. **Newcomb**, *Astronomical Papers, etc. Vol. II; Part VI. The North Polar Distances of the Greenwich and Washington Transit Circles and the Constant of Nutation.* Among the conlusions reached in that paper are the following: pp. 462, 463. * * * * "The observations made by reflection from quicksilver are subject to large systematic errors varying from year to year in a way that it is difficult to account for or to reduce to any well marked law."

"The much greater discordance of the reflex than of the direct observations shows that the former should be entirely thrown out, so far as absolute north polar distances are concerned." Mr. **Chandler** has grouped his data in such a way that it is difficult to compare his results with those published in the annual Washington volumes: but a sufficient number of coincidences in time can be found to show that he has not rejected the reflex observations. It is of course his privilege to exercise an independent judgement in the discussion of his data, but when he dissents from the published conclusions of other investigators, it is surely incumbent upon him to present his reasons for so doing. Following Prof. **Newcomb** in the rejection of the reflex observations, I take from the Washington Observations of 1886 the following annual results for latitude:

	″		″
1866	38.73	1877	39.11
67	39.16	78	38.07
68	38.69	79	40.41
69	38.62	80	36.36
70	38.71	81	39.50
71–72	39.11	82	37.70
73	38.91	83	39.83
74	38.31	84	37.88
75	39.22	85	40.16
76	38.61	86	38.07

These may be considered as still requiring correction for the 427-day period, but their most urgent need is the detection and elimination of the systematic errors which affect them. The only inference which I am able to draw from them, in their present condition, is that the latitude has probably not changed more than three or four seconds during the period over which they extend.

The treatment of the data furnished by the prime-vertical transit requires more careful examination. Here Mr. **Chandler** rests his whole case upon the latitude furnished by the 1845–48 observations of *α Lyrae, compared with the transit-circle work*; i.e., he turns his back upon the most cogent evidence adduced in behalf of a variation of latitude, and does not even refer to its existence save by a reflection cast upon the capacity of the observers. Against this treatment I must protest. The results of observation are entitled to be considered upon their own merits and no code of ethics can justify the condemnation of an observation solely because it was made by a naval officer. Mr. **Chandler** does not profess to have examined or ever to have seen the observations of 1882–84 upon which he thus sets the stamp of his disapproval by crying "Naval Officer." I find from a discussion of 101 observations of *α Lyrae* made in 1882–84, without correction for periodic change of latitude, that the probable error of a single observation is ±0″.25. A large part of these observations were made when the sun was above the horizon, and these may reasonably be presumed less precise than observations made at night (see no. 251 of this Journal). From a discussion of all the data in my possession, I find, as the probable error of a single observation

of this series, ±0″.17, which seems sufficiently small to entitle them to some consideration.

In one of the articles which constitute the subject-matter of Mr. CHANDLER's criticism I have published a comparison of the results furnished by nine stars of the Fundamental Catalog, observed at the mean epochs 1847 and 1883. That comparison I have since extended so as to include all of the 1883 data which are accessible to me, and I reproduce it here, slightly modified by subsequent discussion.

Star	R. A.	1847 Obs.	1847 φ	1883 Obs.	1883 φ	$\Delta\varphi$
	h m		″		″	″
ν Andromedae,	0 50	11	37.19	28	39.12	+1.63
Gr. 1150,	8 25	2	37.67	21	38.11	+0.44
10 *Leon. Min.*,	9 27	2	37.23	10	38.61	+1.11
31 *Leon. Min.*,	10 21	5	37.19	23	39.11	+1.92
17 *H Can. Ven.*,	13 29	3	37.01	13	38.95	+1.91
π Herculis,	17 11	5	37.25	28	38.75	+1.50
e Herc., *C*	17 13	3	37.75	21	38.86	+1.11
θ Herculis,	17 52	3	36.94	19	39.09	+2.15
α Lyrae,	18 33	192	37.24	122	38.89	+1.65
B.A.C. 6365, *C*	18 36	1	[40.86]	19	38.89	—1.97
10 *Cygni*., *C*	20 23	2	38.19	17	38.77	+0.58
10 *Lacertae*,	22 31	8	37.16	38	38.92	+1.16

The declinations and proper motions of all stars, save those to whose names the letter *C* is appended, have been taken from the Fundamental Catalog of AUWERS. The remaining three have been determined by myself, and have been reduced to AUWERS's system. The proper motion of *B.A.C.* 6365 is very poorly determined, depending mainly upon the first Radcliffe Catalogue, although modern determinations give the declination for the epoch 1883 with considerable precision. Although it was observed only once in 1847, I include it in the summary of data.

Mr. CHANDLER states that he obtains from the observations of *α Lyrae* "a latitude greater by 0″.3 or 0″.4 than Prof. COMSTOCK from the same material," — a statement which is not entirely correct, since I have included in my determination 17 observations, made in 1849–50, which Mr. CHANDLER rejects. Their effect is to diminish the latitude. I know no reason for preferring Mr. CHANDLER's result to my own, but I am willing to accept it provisionally, and to compare it with subsequent prime-vertical observations of the same star, but not with the transit-circle work. This comparison follows and I must leave to others the task of interpreting these figures upon any other hypothesis than that of a variation of latitude.

Epoch	1847	1864	1883
		″	
Seconds of φ,	37.65	36.12	38.89
No. of obs.,	175	436	122
Prob. Err. one obs.,	±0″.31	±0″.17	±0″.25

I entirely agree with Mr. CHANDLER in the statement that the precision of the earlier prime-vertical work is much inferior to that of the later observations, an inferiority due in part to the larger accidental error affecting the work of untrained observers, and in part to systematic differences between them. The accidental errors are of small consequence, since the observations are sufficiently numerous to eliminate them: but there may be ground for supposing that the apparent variation of the latitude is due mainly to systematic errors affecting these observations. If such errors are present, it is difficult to see how they could produce an equal effect upon stars in different declinations, unless they arise from errors in the level: but the inclination of the axis was at all times small, varying from plus to minus, and the inequality of the pivots is completely eliminated by the method of observing. The most dangerous sources of error in observations of this kind arise from variations of the azimuth of the instrument and of the clock-rate, and we are fortunately able to show that serious errors of this kind do not affect the observations of 1845–50. The effect of such sources of error upon the latitude is approximately proportional to $\sin(\varphi-\delta)$ and I have therefore divided the available data into zones of declination, from which I obtain the following values of the latitude:

Limits of δ	No. Stars	φ	P. E.
°		″	″
39 . . . 36	19	37.40	±0.05
36 . . . 30	16	36.97	± .11
30 . . . 20	9	37.49	±0.20

While some systematic error may be present in these observations, it is manifestly much less in amount than the difference in the latitudes observed at different epochs.

Melbourne Observations. I have not access to the data and am therefore unable to form any judgement in regard to Mr. CHANDLER's discussion of them.

Madison Observations. The only criticism made upon these by Mr. CHANDLER is that they do not show the 427-day period, and that the introduction of an annual period into the latitudes "seems as likely to introduce as to eliminate error." Taking the second part of the criticism first, I reply that the Madison meridian-circle observations from 1883 to 1890 clearly indicate that in the first half of each year (save 1886 for which there are no data) the latitude was greater than in the second half and within this period an annual variation appears to me justified. But it should not escape notice that the effect of the annual variation, as I have applied it, is to diminish the secular change, and, if it be omitted and a 427-day period introduced, the secular variation will be increased.

I may be permitted to state here that I have diligently sought to fit a 427-day period to the Madison observations, and, like Mr. CHANDLER, I have failed in the attempt: but in one respect my experience has been unlike his. I have discussed the Berlin, Potsdam, Prague and Pulkowa latitude-observations of 1889–90 (*Astr. Nachr. 3025, 3055*), with reference to such a period, and find that they are fairly well

represented by it or rather by one of 422 days. The simultaneous Madison observations are also fairly well represented by the expression derived from the German and Russian work, but it will not fit the earlier Madison observations, nor the Berlin observations of 1885, nor Mr. CHANDLER's own work of that date. Thus in Mr. CHANDLER's notation, save that λ is reckoned from Berlin, the Berlin, Potsdam, Prague and Pulkowa observations furnish the equation

$$\varphi = \varphi_0 - 0''.25 \cos[\lambda + (t - T)\theta], \quad T = 2\,411\,406, \quad \theta = \tfrac{360^\circ}{422}$$

In No. 249 of this Journal, Mr. CHANDLER states, in discussing the Berlin work of 1885, that the epoch of minimum latitude "probably occurred in January or February of 1885" while the above expression places it on 1885 June 25, or June 5 using the 427-day period; *i. e.* if the epochs of maximum and minimum latitude, determined from these observations, be carried back five years by means of a 427-day period, they will put a maximum latitude near the point at which a minimum was observed and a minimum near a maximum.

To slightly vary the form of statement, Mr. CHANDLER's almucantar-observations show (in excellent agreement with the Madison work) that the latitude of Cambridge was a minimum about Oct. 1, 1884. Using a 427-day period, and correcting for longitude, this should make the latitude of Berlin a minimum on 1889 Sept. 13 and 1890 Nov. 14, while observation shows that on the first of these dates the instantaneous value of the latitude exceeded the mean value by $+0''.30$, was a maximum instead of minimum, and on the second date was very slightly in excess of the mean. This admirable series of observations ought therefore to be included in Mr. CHANDLER's statement that the Madison observations, "are the only good series of like observations yet scrutinized in which the 427-day period fails to be manifest."

In view of these circumstances, I cannot consider it a serious reproach to the Madison observations that they do not show a 427-day period; and since Mr. CHANDLER makes a direct appeal for explanation of this fact, I do not hesitate to say that I am satisfied that no such periodic variation existed between 1885 and 1890. The evidence presented by Mr. CHANDLER for the existence of such a periodic term at certain epochs seems to me exceedingly strong, when confined to the dates covered by his data, but there is nothing in the data which requires us to assume that this variation is a permanent feature of the earth's dynamics whose phase may be extrapolated beyond the limits of the data from which it was derived. Mr. CHANDLER has himself indicated that both the period and the amplitude are variable, and the data exhibited above seem to indicate that the character of the variation was not the same between 1885 and 1890 as at some earlier epochs.

The error of most serious consequence, contained in Mr. CHANDLER's paper, remains to be very briefly considered. Referring to the secular variation, he says "it is premature to speculate upon its character until the laws of the periodic variation are more fully understood." No evidence has been adduced from any quarter to show the existence of a periodic variation whose duration is greater than sixteen months, or having a coefficient greater than $0''.5$. Assuming these as maximum values, the mean result of such a series of observations as that of the Washington prime-vertical transit in any of its periods of activity, under the most unfavorable supposition that can reasonably be made regarding the distribution of the observations, cannot be affected by the periodic variation to the amount of $0''.25$ while the difference in the latitudes actually found amounts to six times this quantity. The periodic variation, important and puzzling though it be, is a minor feature, which does not seriously affect the conclusions to be drawn from the data under discussion.

I wish to touch upon only one other point, but that of a more personal nature. I ask Mr. CHANDLER, as a matter of simple justice, to amend his statement, "It appears then that the presumed secular variation must depend entirely upon only seven years' observation with the meridian-circle, and five zenith-telescope determinations at the Madison observatory," so that it may read, The presumed variation depends upon observations at Washington, Cambridge and Madison, which are in substantial agreement both as to magnitude and direction of motion.

Washburn Observatory, 1892 February 2.

ELEMENTS OF THE COMET *e* 1891 (*BARNARD*).

BY ELIZABETH BROWN DAVIS.

The following orbit of Comet *e* 1891, was computed from observations made at the Lick Observatory, on October 2, 4 and 8, and kindly communicated by Prof. E. E. BARNARD, by whom the comet was discovered.

	O — C
$\Delta\lambda \cos\beta$	$-11''.8$
$\Delta\beta$	$-\ 3.0$

$T = $ Nov. 13.265721

$\omega = 269^\circ\ 8'\ 4''.6$

$\Omega = 217\ 51\ 23.9$

$i = 77\ 52\ 32.1$

$\log q = 9.988332$

Los Angeles, Cal., 1891 December.

OBSERVATIONS OF THE PERIODIC COMET OF WOLF (*b* 1891),

MADE AT THE HAVERFORD COLLEGE OBSERVATORY WITH THE 10-INCH EQUATORIAL.

BY F. P. LEAVENWORTH AND WM. H. COLLINS.

1891 Haverford M.T.	✱	No. Comp.	☄ — ✱ $\Delta\alpha$	☄ — ✱ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ	Obs.
Sept. 25^d 12^h 10^m 34^s	1	20 , 5	+0^m 6^s.32	+2′ 0″.0	4^h 19^m 38^s.86	+16° 27′ 58″.4	*n*9.600	0.643	C.
16 16 38	1	5 , 3	+0 20.72	—2 33.4	4 19 53.26	+16 23 25.0	8.593	0.857	L.
16 17 12	2	6 , 4	+0 20.99	—1 30.1	4 19 53.53	+16 23 22.0	8.526	0.546	L.
30 16 47 34	3	5 , 4	+2 25.64	—0 57.2	4 26 30.56	+14 3 31.1	9.194	0.594	L.
Nov. 2 12 38 15	4	12 , 6	—0 23.70	—6 23.4	4 40 35.56	— 3 15 14.9	*n*9.219	0.779	C.
6 11 21 50	5	9 , 4	—4 42.90	—2 46.9	. . . .	. . . .	. . .	. . .	C.
11 16 1 43	6	10 , 6	+2 3.28	—1 47.4	4 36 45.63	— 7 27 16.9	9.486	0.796	C.
Dec. 5 10 19 16	7	10 , 5	—2 15.40	—7 23.5	4 21 44.37	—14 1 14.2	*n*9.109	0.855	C.

Mean Places for 1891.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
1	4^h 19^m 30^s.45	+2^s.09	+16° 25′ 46″.8	+11″.6	Positions from comparisons with Weisse's Bessel IV, 391.
2	4 19 30.45	+2.09	+16 21 40.5	+11.6	
3	4 21 2.74	+2.18	+14 4 16.0	+12.6	Weisse's Bessel IV, 453
4	4 40 56.38	+2.87	— 3 9 5.1	+13.6	Karlsruhe
5	4 43 57.	. . .	— 5 10 7	. . .	SDM. —5° 1046
6	4 34 39.37	+3.06	— 7 25 42.9	+13.4	Seeliger, Vol. II, 887
7	4 23 56.41	+3.36	—13 51 1.7	+11.0	Schjellerup 1438

The $\Delta\delta$ of Nov. 2 was changed by 8 rev. = —138″.7, the record being obscure.

PROBABLE NEW VARIABLE OF LONG PERIOD.

A code telegram was received Feb. 2, from Dr. COPELAND, of the Royal Observatory at Edinburgh, as follows:

"New star of fifth magnitude, two degrees south of χ *Aurigae*. Discoverer anonymous. The spectrum contains bright lines."

The public press announces that several photographs of the region have been taken at the Cambridge Observatory, showing the star.

NEW ASTRONOMICAL WORKS.

Comptes Rendus des Travaux de M., le professeur R. WOLF *dans la domaine de la Physique Solaire, par* A. WOLFER. Archives des Sciences physiques et naturelles. Geneva, Dec. 1891.

An instructive summary and explanation of Prof. WOLF's investigations and results concerning sunspots, since 1852, prepared by the chief assistant at Zurich Observatory, who has himself rendered important aid, in the same field, to the distinguished Director.

The historical order of WOLF's researches, the methods employed, and the latest results deduced from observations to the close of 1883, are very clearly set forth.

The second half-volume of Prof. WOLF's *Handbuch der Astronomie* was issued during the past summer.

CONTENTS.

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CONTRIBUTIONS TO THE KNOWLEDGE OF THE VARIABLE STARS. VI.

By S. C. CHANDLER.

Continued from page 116.

The following table of the variations in the times of *Algol's* minima is taken from the "Table of Normal Epochs" in the investigation in vol. vii (p. 172), already cited. The second, third and fourth columns are copied from those having the same headings there, and the first column gives the corresponding date. The last two columns we shall come to later: they have a like significance to those columns in the tables (pp. 114, 5) i. e., *O* is the deviation of observation from the uniform period hereafter found, and *C* is the corresponding representation of it by the orbit around the unknown distant companion.

Algol: VARIATION IN TIME OF MINIMUM.

Mean Date	Mean Epoch	Wt.	ε	N — N O	 C
1783.9	— 2058.2	12½	—167.9	—124.0	—117.5
1787.1	— 1612.5	4	—143.3	—103.6	—102.2
1790.6	— 1194.3	4½	—122.1	— 86.5	— 85.7
1795.2	— 608.8	3	— 91.7	— 61.7	— 60.0
1799.0	— 118.9	3½	— 68.6	— 43.3	— 34.0
1816.5	+ 2100.2	3	+ 45.7	+ 49.8	+ 80.7
1824.7	3150.0	1	+ 84.1	+ 78.4	+119.7
1841.0	5212.9	13	+186.5	+160.8	+139.9
1843.3	5512.8	5	+193.2	+164.6	+135.9
1847.5	6055.2	14½	+168.8	+135.0	+124.3
1850.9	6486.4	40½	+155.6	+117.6	+111.1
1853.9	6856.7	16	+113.0	+101.4	+ 97.1
1855.1	7019.2	36½	+110.1	+ 97.0	+ 90.9
1857.0	7252.9	20	+127.5	+ 82.2	+ 80.4
1858.7	7477.1	35	+118.1	+ 70.6	+ 70.6
1861.5	7823.9	18½	+107.1	+ 56.3	+ 53.3
1864.5	8225.3	9	+ 95.8	+ 44.1	+ 33.7
1866.2	8435.1	28½	+ 92.5	+ 35.8	+ 22.2
1869.3	8825.1	27½	+ 84.1	+ 23.7	+ 1.1
1871.4	9081.7	24½	+ 73.0	+ 10.1	— 10.8
1872.8	9267.6	17½	+ 67.0	+ 2.4	— 23.2
1874.2	9451.2	23	+ 61.2	— 5.2	— 32.3
1876.2	9712.9	12	+ 37.6	— 31.3	— 45.5
1878.8	10035.1	10½	+ 12.2	— 59.8	— 62.0
1882.3	10473.0	15½	— 11.7	— 90.9	— 82.6
1887.1	+11103.0	8	— 66.1	—118.4	—107.4

To develop the considerations and processes by which I have been led to the conclusions outlined at the beginning, let us assume, first, that known phenomena prove beyond reasonable doubt that the periodical obscuration of *Algol's* light is caused by interposition of a body darker than itself, revolving about it according to the laws of gravitation. Whatever the nature of the pure elliptic motion, the times of conjunction must follow each other at exactly equal intervals, unless, (*a*), one or both components are not spherical; or, unless, (*b*), there is at least one more body in the system. While by (*a*), inequalities in the times of conjunction would necessarily result, this hypothesis seems to be insufficient, since it would be inadequate to explain the character and magnitude of the observed irregularities; and it could not account for the observed variations in the phase. Regarding (*b*), then, as the only natural hypothesis, what is the relation of the third body to the system? First, it cannot, for obvious reasons, revolve between *Algol* and the occulting satellite. Secondly, it does not revolve outside in very close proximity, since the resultant principal inequalities in the motions of the occulting satellite would have periods of relatively short duration. It seems probable, therefore, that the unknown body lies at such a distance from the others that its disturbing action is small compared with the direct action, and that we may properly treat the problem, at all events provisionally, as if the motion were one of *Algol* and its close companion, regarded as a single mass, around the common center of gravity of the system of the three (or more?) bodies. At least, if this is not the necessary conclusion, it is the hypothesis which we must first follow out, as the most plausible, until we come to a result involving such contradiction as to compel us to abandon it for some other. I proceed therefore to examine it mathematically and numerically.

Let us take the center of such a system as the origin of rectangular coordinates, whose x-y plane is perpendicular to our sight-line, and whose x-z plane is the meridian; x being positive towards the north, y towards increasing

right-ascension, and z outwards into space. *Algol's* coordinates will be,

$$(1)\qquad \begin{aligned} y &= r(\cos u \sin \Omega + \sin u \cos i \cos \Omega) \\ x &= r(\cos u \cos \Omega - \sin u \cos i \sin \Omega) \\ z &= r \sin u \sin i \end{aligned}$$

or, putting

$$(2)\qquad \begin{aligned} \cos \Omega &= j \sin J, & -\cos i \sin \Omega &= j \cos J \\ \sin \Omega &= k \sin K, & \cos i \cos \Omega &= k \cos K \end{aligned}$$

$$(3)\quad y = rk \sin(K+u), \quad x = rj \sin(J+u), \quad z = r \sin i \sin u$$

and the corresponding effects, η on the right-ascension, ξ on the declination, and ζ on the time of minimum, will be,

$$\eta = \Pi rk \sin(K+u) \frac{\sec \delta}{15}, \qquad \xi = \Pi rj \sin(J+u),$$

$$(4)\qquad \zeta = 8^m.3\, r \sin i \sin u.$$

where Π is the annual parallax of the star.

Further let α_0, δ_0, be the place of the center of gravity, or origin, for 1875.0, and μ, μ', its rectilinear and uniform annual proper motion in these coordinates, on the face of the sky. By virtue of any uniform translatory motion of the system in the z-coordinate, the mean value of the apparent interval between two successive minima of *Algol's* light-variation, freed from the aberrational effect of its orbital motion around the distant companion, will differ from the actual time of sidereal revolution of the close companion around *Algol* by a constant quantity. Call this mean apparent period P_0, and let N_0 be the apparent time, also freed from this aberrational effect, of the first minimum which occurred after 1800 Jan. 0, and E be the number of periods elapsed at the time t. Then for this time we have the right-ascension, declination and time of minimum, of *Algol*,

$$\begin{aligned} \alpha &= \alpha_0 + \mu(t-1875) + \Pi rk \sin(K+u) \frac{\sec\delta}{15} \\ \delta &= \delta_0 + \mu'(t-1875) + \Pi rj \sin(J+u) \qquad (5) \\ N &= N_0 + P_0 E + 8^m.3\, r \sin u \sin i \end{aligned}$$

which must satisfy the observed values of those quantities, when the true place and proper motion of the center of gravity, elements of the orbit, and parallax, are inserted.

Differentiating (1) and putting for brevity,

$$K' = K + v + \omega, \quad J' = J + v + \omega, \quad \text{we get}$$

$$(6)\qquad \begin{aligned} dy &= k \sin K'\, dr + rk \cos K'\, dv + rk \cos K'\, d\omega + rj \sin J'\, d\Omega - r \sin i \sin u \cos \Omega\, di \\ dx &= j \sin J'\, dr + rj \cos J'\, dv + rj \cos J'\, d\omega - rk \sin K'\, d\Omega + r \sin i \sin u \sin \Omega\, di \\ dz &= \sin i \sin u\, dr + r \sin i \cos u\, dv + r \sin i \cos u\, d\omega + r \cos i \sin u\, di \end{aligned}$$

and, from the relations of elliptic motion, the partial differential coefficients,

$$\begin{aligned} \frac{dr}{de} &= -a \cos v & \frac{dv}{de} &= \frac{1}{\sin 1^\circ} \sec^2\varphi (2 + \sin\varphi \cos v) \sin v \\ \frac{dr}{dm} &= a \tan\varphi \sin v (t-T) \sin 1^\circ & \frac{dv}{dm} &= \frac{a^2 \cos\varphi}{r^2} (t-T) \\ \frac{dr}{dT} &= -a\, m \tan\varphi \sin v \sin 1^\circ & \frac{dv}{dT} &= -\frac{a^2 \cos\varphi}{r^2}\, m \\ \frac{dr}{da} &= \frac{r}{a} \qquad (7) & \frac{dv}{da} &= 0 \end{aligned}$$

where a and r are expressed in the earth-sun distance unit; m is the mean annual motion in degrees; Ω is reckoned in position-angle from the north towards the east, and is the point where *Algol*, going outwards, passes the plane through the center of gravity perpendicular to our line of vision; i is the inclination to this plane; v and ω being reckoned in the direction of the motion.

In the numerous trials, by different methods, to get approximate values of the unknowns with which to compute the differential coefficients, it was found that, while there was some indication of moderate ellipticity with a periastron somewhere about 315°–345°, the eccentricity was too uncertainly reflected in the observed data to make it worth while to determine it. I therefore concluded to be content, in the present provisional calculation, with the best circular orbit which would reasonably satisfy the observations. Accordingly, making the appropriate substitutions and simplifications in the above formulas, we have the following equations; where T becomes the time of passing the ascending node; also, for convenience, we express the mean distance in geocentric arc, in the equations in α and δ, and in light-time in the equation in N, and introduce the correction to P corresponding to the year, instead of that for the single period, or,

$$a'' = \Pi a, \qquad a' = 8^m.3\, a, \qquad \Delta P' = \frac{365.25}{P}\, \Delta P \qquad (8)$$

The equations actually used, are then

$$(9)\qquad \begin{aligned} &15 \cos\delta\, .\Delta\alpha_0 + 15 \cos\delta (t-1875) .\Delta\mu \;\; - a'' m k \sin 1^\circ \cos K' .\Delta T + k \sin K'\, \Delta a'' \;\; + a''(t-T) k \cos K' \sin 1^\circ\, \Delta m \\ &\qquad\qquad - a'' \sin i \sin M \cos \Omega \sin 1^\circ\, \Delta i \;\; + a'' j \sin J' \sin 1^\circ .\Delta\Omega \;\; = 15 \cos\delta\, .\Delta\alpha \\ &\Delta\delta_0 + (t-1875) .\Delta\mu' \;\; - a'' m j \sin 1^\circ \cos J' .\Delta T + j \sin J' .\Delta a'' \;\; + a''(t-T) j \cos J' \sin 1^\circ .\Delta m \\ &\qquad\qquad + a'' \sin i \sin M \sin \Omega \sin 1^\circ\, \Delta i \;\; - a'' k \sin K' \sin 1^\circ .\Delta\Omega \;\; = \Delta\delta \\ &\Delta N + (t-1800) .\Delta P' \;\; - a' m \sin 1^\circ \sin i \cos M .\Delta T + \sin i \sin M\, \Delta a' \;\; + a'(t-T) \sin i \cos M \sin 1^\circ .\Delta m \\ &\qquad\qquad + a' \cos i \sin M \sin 1^\circ .\Delta i \;\; = \Delta N \end{aligned}$$

It is unnecessary to give more than a brief summary of the course pursued in arriving at the final values of the unknowns. This was a work of some difficulty, from their involved relations and the fact that the observations cover scarcely a full period of revolution. It could be seen at once that this must be between 120 and 140 years; and starting from this, and by dint of various hypotheses as to the mean proper motions, tested by successive approximations, and reference of the data in turn to each of the planes of projection, by graphical processes combined with a prelimi-

nary solution resembling the one finally used, and hereafter given, I arrived at the elements (1) below:

ELEMENTS I.

$U = 125$ yrs.
$T = 1801.6$
$\Omega = 73°$
$i = 110°$
$a = 16.0$
$a'' = 1''.60$
$\pi = 0''.10$
$\alpha_0 = 3^h\,0^m\,2^s.590 - 0^s.00114(t-1875)$
$\delta_0 = +40°\,28'\,20''.86 \quad +0''.0082(t-1875)$

$N_0 = 1800$ Jan. $1^d\,18^h\,15^m.6$ (Paris) $+ 2^d\,20^h\,18^m\,56^s.115\,E$
$M = 2°.88(t-1804.6)$
$\eta = (9.12976)\sin(M+95°\,58'.2)$
$\xi = (9.84633)\sin(M+11°\,17'.6)$
$\zeta = (2.09619)\sin M$

With these elements normal places and epochs were formed, giving the following values of the absolute terms in the equations of condition. Two sets are given for the right-ascensions and declinations: n corresponding to the actual means, by weights, in the tables of observation: n' corresponding to differences from an adjusted curve. The left-hand members of the equations, computed from Eq. (9), are added immediately after.

		$15\cos\delta\,\Delta\alpha$	
t	Obs.	n	n'
		$''$	$''$
1753.9	2	−0.24	−0.21
1802.0	6	+1.26	−0.40
1829.5	14	−1.32	−1.01
1846.8	30	−0.31	−0.43
1859.8	18	+0.02	+0.11
1865.5	30	+0.27	+0.17
1874.8	34	+0.16	+0.10
1883.0	19	−0.22	−0.14

		$\Delta\delta$	
t	Obs.	n	n'
		$''$	$''$
1754.1	1	−0.02	−0.02
1805.5	4½	+0.06	−0.09
1821.6	21	−0.19	−0.17
1838.9	26	−0.10	+0.02
1846.6	32	+0.30	+0.09
1861.3	17	−0.05	0.00
1864.6	38	0.00	+0.05
1874.7	36	+0.12	+0.18
1882.4	22	+0.33	+0.30

		ΔN
t	Obs.	n
1781.7	16½	+ 6.0
1791.5	11	+18.2
1818.5	4	−12.4
1841.6	18	+45.5
1849.1	22	+29.7
1854.7	52½	+21.7
1858.1	55	+18.0
1864.4	56	+22.6
1870.3	52	+31.1
1874.2	52½	+27.8
1880.9	26	− 8.0
1887.1	8	−51.0

11.411 $I\alpha_0$	−1380.7 $I\mu$	−0.0497 IT	−0.7371 Ia''	−0.8712 Im	+0.0043 Ii	−0.0119 $I\Omega$	$= n$	$\sqrt{p} = 2$
11.411	− 833.0	− .0020	+ .9612	− .0018	+ .0010	+ .0069	"	2
11.411	− 513.5	+ .0755	+ .2051	− .6532	− .0073	+ .0112	"	4
11.411	− 319.5	+ .0613	− .5851	− .0898	− .0065	+ .0035	"	5
11.411	− 171.2	+ .0201	− .9285	− .3850	− .0028	− .0043	"	4
11.411	− 114.1	− .0018	− .9613	+ .0389	− .0006	− .0071	"	5
11.411	0.0	− .0365	− .8478	+0.8892	+ .0029	− .0110	"	6
11.411	+ 91.3	−0.0607	−0.5951	+1.6534	+0.0055	−0.0122	"	4

1 $I\delta_0$	− 121 $I\mu'$	+0.0078 IT	−0.4278 Ia''	+0.1361 Im	−0.0115 Ii	+0.0201 $I\Omega$	$= n$	1
1	− 70	− .0252	+ .3069	+ .0020	+ .0011	− .0265	"	2
1	− 50	+ .0058	+ .1328	− .0100	+ .0212	− .0120	"	4
1	− 36	+ .0273	+ .2786	− .3246	+ .0218	+ .0068	"	5
1	− 28	+ .0337	+ .1301	− .1911	+ .0215	+ .0161	"	5
1	− 14	+ .0320	− .1860	− .6291	+ .0072	+ .0261	"	4
1	− 10	+ .0290	− .2491	− .6051	+ .0031	+ .0268	"	6
1	0	+ .0156	− .3932	− .3808	− .0091	+ .0237	"	6
1	+ 7	+0.0026	−0.1376	−0.0689	−0.0171	+0.0172	"	5

1 IN_0	− 15 IP'	−3.388 IT	−0.7909 Ia'	− 23.408 Im	+0.6672 Ii		$= n$	2
1	− 5	−5.482	− .1568	− 19.224	+ .3854		"	2
1	+ 18	−1.803	+ .6041	+ 23.181	− .5099		"	1
1	+ 12	+1.788	+ .9007	− 22.969	− .7599		"	2
1	+ 49	+3.876	+ .7389	− 59.885	− .6233		"	2
1	+ 55	+5.093	+ .5185	− 88.603	− .4627		"	3
1	+ 58	+5.642	+ .4108	−104.804	− .3165		"	3
1	+ 61	+6.215	+ .1272	−129.051	− .1073		"	3
1	+ 70	+6.192	− .1505	−141.254	+ .1270		"	3
1	+ 74	+5.878	− .3283	−142.040	+ .2770		"	3
1	+ 81	+1.823	− .6008	−127.782	+ .5068		"	2
1	+ 87	+3.361	−0.7934	− 96.281	+0.6693		"	1

The last column gives the square roots of the weights used to render the different data homogeneous in this respect. It was assumed that, for a star at 40° declination, both coordinates of the catalogue-positions are of equal weight, for the same number of observations. The relation to these of the weights for the normal epochs of minima, were assigned by a consideration of the relative effect of their errors, when measured in the same unit.

A rigid solution of these equations has not been made, as it would hardly repay the labor, the results of this paper being merely preliminary to a more exhaustive investigation of more complete data. From the nature of the orbit we may expect that in a few years the apparent period of light-variation, now near its minimum value, will begin to increase, and also that the irregularity of the proper motion will manifest itself by an increase of the right-ascension. This will remove a large part of the uncertainty of the elements here found, especially of the important one of the mean motion. For the present we obtain provisionally the following

ELEMENTS II.

$U = 130.91$ yrs.
$T = 1804.0$
$\Omega = 65^\circ.0$
$i = 110^\circ.0$
$a = 19.0$
$a'' = 1''.33$
$\Pi = 0''.070$
$\alpha_0 = 3^h\ 0^m\ 2^s.570 - 0^s.00100(t-1875)$
$\delta_0 = +40^\circ\ 28'\ 21''.06 + 0''.0120(t-1875)$
$N = 1800$ Jan. $1^d\ 18^h\ 22^m.0$ (Gr. M.T.) $+ 2^d\ 20^h\ 48^m\ 56^s.00\,E$
$M = 2^\circ.75(t-1801.0)$
$\eta = (9.02926)\ \sin(M+99^\circ\ \ 3'.7)$
$\xi = (9.84328)\ \sin(M+53^\circ\ 44'.5)$
$\zeta = (2.15511)\ \sin M$

It is interesting to note that these elements give a minimum ($E = -16451$) 1671 Nov. $8^d\ 13^h.4$, and that on this evening MONTANARI remarked with surprise that the star, which is generally 2^M, was but 4^M, and scarcely greater than *ρ Persei*. This was more than a century earlier than GOODRICKE's discovery. Unfortunately MONTANARI does not give the hour of the observation, which however confirms the general correctness of the elements, although we can make no precise use of it.

The comparison of the elements with the observations is made in the last two columns of the tables on pp. 114, 115 and 121. The systematic deviations which still remain I have thus far been unsuccessful in reducing by a circular orbit, nor indeed are they of a nature apparently to be accounted for by eccentricity. So far as the times of minima are concerned, the deviations are much beyond the range of errors of observation. Of course we are by no means yet in a position to say that they are inconsistent with purely elliptical motion, yet there is a presumption that this may prove to be the case, which is strengthened by the nature of the numerical law developed in vol. VII. Little inclined as we may be to let interpretation outrun the facts, it must be admitted that, if the results of this paper are accepted, there is enough analogy between the primary and secondary motions here exhibited and those of our solar system, to make it not improbable that the system of *Algol* consists of more than three bodies. The dimension of the orbit of the satellite relative to that of *Algol* around the primary, 1 ÷ 2500, is such that the disturbing force must be nearly nothing, even if the unknown mass be enormously greater than we can reasonably suppose. Therefore, if in future we discover evidence of deviation from pure elliptic motion, we must naturally look to a fourth body as its cause. From the accuracy with which the observations of minima can be made, the suggestion that this may be done within a comparatively few years is not as chimerical as may at first appear.

But the whole subject, in its various phases, opens up a new and large field for speculation, which I leave to the cultivation of those who are inclined to that recreation.

Meanwhile the present discovery — if it prove to be such — has a much wider cosmological meaning than the mere explanation of the phenomena of this star. It has been shown by the writer (*A.J.*, VII, 129; VIII, 130; IX, 49, 92, 97), that four of the variables of this type (*U Ophiuchi*, *U Cephei*, *U Coronae* and *Y Cygni*) exhibit irregularities analogous to those of *Algol*. SCHÖNFELD has done the same for another (*λ Tauri*); and there is some evidence of the sort in the case of *S Cancri*. I have failed to find the phenomenon only in *δ Librae*. The remaining two variables of the type (*R Canis Majoris* and *S Antliae*) have been too recently discovered for us to assert anything with regard to the constancy of their periods. Thus, in at least six, possibly seven, out of eight stars, the phenomenon is present. The principle of attributing like effects to like causes allows us to assume with high probability that it is general, and that, therefore, all the stars of this class have similar motions, namely, one around a near companion, the other a common motion of these two bodies around a distant one. If we further reflect that only those stars which have companions moving in or near the plane of our line of vision, large enough to cut off a perceptible proportion of their light, can ever become visible to us as variables of this character; and further that, on account of the peculiar difficulty attending discovery of variation of the sort, the number of actually existing variables of this type is doubtless very large indeed, much larger than the numerical proportion to the other known variables would indicate; we must naturally conclude that the kind of motions here shown to exist in the case of *Algol*, and giving evidence of complex planetary systems somewhat like our solar system, are by no means exceptional, but possibly the rule in the stellar universe.

Before concluding, there is a practical point which I desire strongly to urge upon the attention of astronomers provided with heliometers or other means of nice micrometric observation. Heretofore no such measurement has been undertaken of variables of the *Algol*-type. It is hoped that this paper will have the effect of leading research in this direction. The data thus provided, when combined with the corresponding observations of the variation of the times of minima, as in the present instance, will much extend our knowledge of this new class of celestial motion.

I would especially indicate the star *Y Cygni* as perhaps the most interesting for immediate research of this sort. I have elsewhere shown that the cyclical fluctuation in this case is wonderfully rapid, being completed in about 600 single periods, or two and a half years. The amplitude is about four hours, so that, if the present theory of the cause is correct, the size of the orbit is at least between those of *Saturn* and *Uranus*, larger if its plane is considerably inclined to our line of vision. Micrometrical measures would therefore be likely to give significant results within a short time, possibly in a few months. If the research gave favorable results in this instance it could then be extended to *λ Tauri*, which appears to be also a promising candidate.

It would also be interesting to confirm by direct observation the annual parallax of *Algol* here theoretically found, although its value, 0″.07, is rather below the limit of certain measurement.

I now add, as an essential part of the proof of the irregularity of proper motion, the table of data for the systematic corrections used on pp. 114, 115.

The weights, according to which the means were taken, are omitted for want of room. For the same reason, the 13 comparison-stars are indicated in the first column by an ordinal number, assigned according to their right-ascensions. The list given on p. 11 should have included *η Tauri*. Otherwise the construction has been already fully explained.

DETERMINATION OF SYSTEMATIC CORRECTIONS.

d'AGELET.

	s	″
1	+0.31	—1.7
2	+ .54	—2.2
4	+ .49	—7.0
6	+ .01	—5.8
7	+ .19	[+2.7]
8	+ .57	—0.6
10	+ .16	—3.8
11	+ .41	—2.2
12	+ .40	—1.8
13	+0.20	+1.1
	+0.30	—2.93

PIAZZI.

1	+0.31	—0.3
2	— .06	—3.7
3	+ .32	—1.3
4	+ .14	—1.9
5	+ .48	0.0
6	+ .27	—2.2
7	+ .30	—2.0
8	+ .13	+0.7
9	+ .54	—1.1
10	— .45	—1.9
11	+ .25	—1.3
12	+ .11	—1.7
13	+0.30	—0.5
	+0.17	—1.35

GROOMBRIDGE.

1	+0.20	—1.1
3	+ .50	—0.2
5	+ .56	—2.1
6	+ .11	—1.5
7	+ .21	+0.6
8	+ .34	—0.8
9	+ .39	+1.2
12	+0.29	—0.3
	+0.32	—0.52

BESSEL 1820–21.

	s	″
1	–	—0.33
7	–	—0.29
12	–	—1.39
		—0.64

STRUVE.

1	+0.10	—0.74
3	+ .07	—0.08
4	+ .14	+0.28
7	.00	—0.07
8	+ .11	—0.72
10	+ .01	—0.84
11	+ .07	—1.39
12	+0.11	—0.81
	+0.07	—0.40

POND.

1	+0.19	—1.11
2	— .13	—1.37
3	+ .26	—0.22
4	+ .05	—0.92
5	+ .02	—0.85
6	— .05	—2.57
7	+ .02	—0.57
8	— .01	—0.72
9	+ .06	—0.80
10	+ .10	—2.01
11	+ .11	—1.99
12	+ .11	—2.11
13	+0.13	—0.85
	+0.07	—0.99

CAMBR. AIRY.

1	+0.11	—1.76
5	+ .16	–
7	+ .06	—0.92
10	+0.07	+0.49
12	–	—1.85
	+0.09	—0.81

RUMKER.

	s	″
1	—0.08	—2.90
3	— .09	+0.86
4	+ .01	+0.51
5	+ .14	—0.19
6	— .18	+3.19
8	— .04	—0.66
10	+ .11	—0.01
11	+ .01	—0.25
12	— .01	—1.20
13	—0.03	—0.66
	+0.01	—0.41

CHALLIS.

3	+0.16	—0.32
7	.00	—0.87
8	–	—1.54
9	+ .04	—0.46
10	+0.05	—1.03
	+0.06	—0.85

GREENWICH 1840.

1	+0.11	—0.23
2	+ .05	—0.23
3	–	—1.00
4	–	—0.51
5	–	—0.30
7	+ .10	+0.23
8	+ –	—0.35
9	+ .12	–
10	+ .11	[—3.12]
11	+0.04	—0.75
12	–	—0.78
	+0.10	—0.35

RADCLIFFE 1845.

1	+0.12	+0.03
3	.00	+1.19
5	+0.12	—0.30

RAD. — CON.

	s	″
6	+0.02	—1.85
7	+ .11	—0.19
8	+ .07	+0.88
9	+ .10	—1.11
10	+ .03	—1.21
12	+0.06	—1.12
	+0.07	—0.40

PARIS I.

1	+0.07	—0.17
2	+ .10	–
3	+ .46	–
4	+ .01	+0.72
7	+ .07	+0.21
8	+ .05	+0.08
9	+ .07	–
10	+ .05	—0.04
11	+ .06	—0.11
12	+ .08	—0.02
13	+0.14	–
	+0.08	+0.09

GREENWICH 1845.

1	0.00	—0.42
3	+ .11	—0.19
4	+ .02	+0.91
5	+ .20	+0.78
7	.00	+0.01
8	+ .18	—0.12
9	–	+0.64
10	+ .07	—0.30
12	+0.10	+0.04
	+0.07	0.00

PULKOWA 1845.

1	+0.07	—0.12
2	+ .06	—0.15
3	+0.06	+0.02

PULKOWA — CON.

	s	″
1	+0.06	+0.29
5	+ .07	—0.11
6	+ .03	—0.16
7	+ .05	+0.30
8	+ .06	+0.13
9	+ .01	+0.24
10	+ .05	+0.02
11	+ .02	—0.42
12	+ .04	+0.20
13	+0.06	–
	+0.05	+0.05

GREENWICH 1850.

1	+0.18	—0.69
2	+ .07	—0.82
3	–	—0.71
4	+ .05	+0.37
5	+ .16	—1.29
6	–	+1.86
7	+ .07	—0.09
8	+ .15	0.18
10	+ .05	—0.05
11	+0.10	—1.03
	+0.09	—0.19

RADCLIFFE 1860.

1	+0.16	+0.31
2	— .07	—1.52
3	+ .08	+0.84
4	— .02	—0.71
6	+ .05	–
7	+ .01	+0.44
8	+ .12	0.02
10	+0.05	—1.20
	+0.05	—0.47

GREENWICH 1860.

1	+0.03	0.33
2	— .04	+0.77
4	+0.09	—0.45

GREENSW. — CON.

	s	″
5	0.00	—0.07
6	— .05	—0.31
7	+ .03	+0.16
9	— .10	–
10	+0.03	+0.13
	+0.02	—0.06

PARIS II.

1	+0.06	—0.09
2	— .15	—1.52
4	+ .07	+0.29
6	–	+0.38
7	+ .02	+0.04
8	+ .10	+0.21
9	+ .07	+0.31
10	+ .06	—0.30
11	+ .05	—0.36
12	+ .10	+0.16
13	+0.22	+0.16
	+0.06	+0.01

GREENWICH 1864.

1	+0.07	—0.12
2	+ .03	—0.11
4	+ .02	+0.31
7	+ .10	+0.26
8	+0.05	—0.35

GREENSW. — CON.

	s	″
9	—0.03	+0.01
10	+ .03	—0.01
11	+ .06	—0.16
13	—0.01	—0.29
	+0.05	—0.08

BONN.

7	+0.03	—0.10
10	+0.03	0.20
	+0.03	—0.15

LEIPZIG.

7	—0.01	—0.29
10	—0.02	—0.71
	—0.03	—0.50

LEIDEN.

2	–	—0.11
7	–	—0.08
8	–	—0.13
	–	—0.32

GREENWICH 1872.

1	+0.03	—1.18
2	+ .05	—0.90
3	+0.01	—1.12

GREENSW. — CON.

	s	″
1	+0.03	—0.09
5	+ .07	—0.51
6	— .01	—0.39
7	+ .06	—0.73
8	+ .07	—0.12
9	+ .01	—0.56
10	+ .01	—0.58
11	+ .01	—0.69
12	+ .08	—1.06
13	+0.05	—0.61
	+0.01	—0.69

PARIS III.

1	—0.10	—0.21
2	+ .08	—1.30
4.	+ .05	—1.30
6	+ .02	+0.41
7	.00	+0.32
8	+ .09	—0.16
10	+ .03	—0.03
11	+ .03	—0.15
12	— .04	—0.97
13	+0.22	—0.41
	+0.03	—0.43

ROGERS.

1	+0.05	+0.36
2	+0.02	+0.66

ROGERS — CON.

	s	″
3	+0.01	—0.12
4	+ .01	—0.06
5	— .01	+0.17
6	.00	—0.06
7	+ .02	—0.23
8	+ .01	—0.30
9	— .01	—0.35
10	— .01	+0.14
11	+ .02	—0.55
12	— .01	+0.26
13	—0.02	+0.92
	+0.01	0.00

PULKOWA 1875.

1	—0.03	+0.09
2	+ .01	0.00
3	— .01	+0.30
4	.00	+0.10
5	+ .01	+0.25
6	— .03	+0.31
7	— .01	+0.22
8	— .02	+0.14
9	+ .06	—1.36
10	— .01	+0.17
11	— .02	+0.25
12	— .01	+0.73
13	—0.03	+0.09
	—0.02	+0.19

GREENWICH 1880.

	s	″
1	+0.01	—0.16
2	— .05	—0.09
3	+ .08	—0.14
4	+ .01	+0.09
6	— .01	—0.35
7	— .06	+0.11
8	+ .01	+0.21
9	+ .11	—0.58
10	+ .01	+0.43
11	+ .01	—0.78
12	+ .08	—0.10
13	+0.06	—0.21
	+0.02	—0.10

WASHINGTON '82–'86.

1	—0.06	+0.61
2	+ .01.	+0.35
3	— .11	—0.25
7	–	—0.21
8	–	—0.19
10	–	+0.12
11	–	+0.53
12	+0.04	+0.03
	—0.03	+0.10

ON THE PERIOD OF 3567 *V LEONIS*.

BY HENRY M. PARKHURST.

From frequent observations between 1891 Feb. 11 and May 28, chiefly photometric, I deduced a maximum on April 11, with a brightness of $8^{\rm M}.3$. I am not aware of any previously determined maximum, although there had been observations from 1855. To determine the period it became necessary from the light-curve to make corrections for former observations. But the light-curve has been in several respects peculiar, making such corrections uncertain. A period of 271 days satisfactorily explains all the observations, kindly communicated to me by Dr. CHANDLER, excepting that in 1883 February, and in 1884 June, the variable seems to have been a magnitude too faint; whereas in 1887 May, it rose in brightness in nine days a magnitude more than in the light-curve of 1891.

I have also observed it, chiefly photometrically, commencing 1891 Nov. 26, when it was certainly $<10^{\rm M}.5$, and was invisible in the horizon, until 1892 Feb. 16, when it was $<11^{\rm M}$. The highest point observed was Dec. 28, 13 days before the predicted time, and a magnitude fainter. The light-curve of last year suggests an explanation of this. Omitting the observations from April 6 to April 22 inclusive, the resulting maximum is 12 days earlier, and the general form of the curve the same as in the present year, but half a magnitude brighter. But these omitted observations show a sudden rise of more than half a magnitude in three days, and a fall nearly as rapid, which have no counterpart during the present maximum. I suspect similar outbursts in 1855, 1882, and in 1887.

The prior observations tending to fix the period, referred to the elements of 1891, are as follows:

1855 April 20. DM. estimate $9^{\rm M}.0$. 12 days after maximum.

1856 Jan. 4. DM. estimate $9^{\rm M}.0$. 7 days after the maximum.

1880 March 3 (and later). Invisible in the Berlin meridian circle. 54 days after the maximum.

1881 Feb. 21 (to April). Invisible in the Berlin meridian circle. 134 days after the maximum.

1882 April 4 (and 5). BECKER, estimate $8^{\rm M}.7$. 6 days before the maximum.

1883 Feb. 23 (and later). CHANDLER, $<12^{\rm M}.0$. 45 days after maximum.

Oct. 31 (and later). CHANDLER, estimate $9^{\rm M}.3$. 21 days after the maximum. Later observations indicate diminishing light.

1884 June 26. Chandler, estimate $9^{M}.7$. 14 days before the maximum.

1886–7. M.P. observations. Variable probably not seen.

1887 May 15. Parkhurst, $12^{M}.7$. 57 days before the maximum.

May 24. Parkhurst, $11^{M}.5$. 18 days before the maximum.

1888 March 17. M.P. $9^{M}.85$. 21 days before the maximum.

At the next maximum, the variable will only be visible after midnight, first becoming equal to the smallest neighboring DM. stars late in September.

173 *Gates Ave., Brooklyn, N. Y.*, 1892 *February* 17.

OBSERVATIONS OF THE VARIABLE STAR *U GEMINORUM*, 1891–92.

By PAUL S. YENDELL.

I have had the good fortune to obtain observations of this variable at both the maxima which have occurred during the present season.

When looked for on Oct. 28, 1891, the star was not seen, the limit of visibility on that occasion being about $11^{M}.0$, as estimated from the comparison-stars seen: the next occasion on which observation was possible, was Nov. 3, when the star was seen, its estimated magnitude being $10^{M}.1$. The estimates are as follows, the nomenclature used being Knott's:

		M	w	
Nov. 3.469	*d2e*, *e4e*	10.1	1	
4.472	between *d* & *e*, nearer *e*	10.5?	2	* low and hazy
8.458	not seen: saw *e*			

This appears to be part of the decline from the maximum observed by Dunér (see *A.J.*, p. 110, current volume).

On 1891 Dec. 28, the sky being very clear, so that Knott's stars *f*, *h* and *g*, were steadily held (*h* and *g* being according to Baxendell $12^{M}.3$), the variable was held at intervals for about a second at a time, during several minutes; its magnitude must have been as low as $12^{M}.5$; the star's place was identified with as much precision as my means permitted.

During December, 1891, and January, 1892, observations were very badly broken up by unfavorable weather, but whenever observation was possible, the star was looked for; on Jan. 21 the star was not seen; limit of visibility $< 10^{M}.5$. From that time till the present date, estimates are

			M	
Jan. 25.292	*a1e*, *e2e*		9.0	1
* .510	*e1e*		9.6	2
26.289	*a3e*, *e3e*		8.9	1
27.395	*a5e*, *e1e*		9.1	4
31.306	*d4e*, *e4e*		10.1	1
Feb. 1.340	*e2-3f*		11.0	3
†1.343	glimpsed		12.0	2

* Star very high, making the position of the head constrained and observation therefore uncertain.

† Moon 1st quarter.

These observations appear to indicate a maximum of $8^{M}.9$ on or about Jan. 26.5.

Dorchester, Mass., 1892 *February* 6.

NEW DOUBLE STAR, 26 *AURIGAE*.

By S. W. BURNHAM.

This star has been known as a wide pair since its discovery in 1783 by Sir William Herschel, and it is included in the subsequent catalogues of Sir James South, and Struve (♅ III, 61 = S. 492 = Σ753). In 1872, while looking at it with the 6-inch, I noted another star which appeared to be about twice as far from the primary, and entered it as no. 90 of my *Second Catalogue*. I was not aware at that time that this companion had been previously seen and mentioned by Lord Wrottesley, in measuring the Herschel companion. Both of these stars are much too far from the primary to make it in the least probable that they have any connection with each other. 26 *Aurigae* and the old companion could hardly be called a double star with the modern limitation, and of course the other star was still less worth noting.

Not long ago this star was accidentally looked at with the 36-inch refractor, and I saw at once that the large star was really double, being made up of two nearly equal components. I have since made the following measures:

A and *B*.

1891.906	316.6	0.15	6 . . . 6.3
1892.017	313.9	0.11	5.5 . . . 5.7
1892.022	311.7	0.11	6 . . . 6.3
1892.057	312.3	0.18	5 . . . 5.5
1892.00	311.4	0.15	5.6 . . . 6.0

This is certain to be a binary, and is the kind of star where one would look for rapid motion. It is probable that the distance is never much more than a quarter of second, or it would have been detected before by some of the many observers who have measured the Herschel companion.

There has been no change whatever in the Herschel star from the first accurate measures. I give below enough of the observations to show the absence of any relative motion. The two sets of measures of *D* are all that have been [illegible]

of this star. The first distance, by a clerical error in reducing the observation, was originally printed as 25″.86 (*Mem. R. A. S.* XLIV). It should be, as given below, 31″.47.

A. B AND *C* (= Σ 753).

1828.61	268.0	12.34	5.8 . . . 8.0	Σ 3*n*
1865.52	268.0	12.39	5.7 . . . 7.8	*I* 3*n*
1880.95	268.3	12.17	. . .	Sp. 3*n*
1891.95	268.3	12.25	. . . 8.7	β 4*n*

Mt. Hamilton, 1892 *January* 30.

A. B AND *D* (= β 90).

		″		
1877.87	113.2	31.47	. . . 11.5	β 1*n*
1891.97	112.7	32.33	. . . 11.0	β 3*n*

There is no necessity for any further measures of these stars. The close pair, however, will require special attention, as it is not improbable that the measures of next year may show considerable motion.

NEW ASTRONOMICAL WORK.

Observations de Nébuleuses, et d'Amas Stellaires, par M. G. BIGOURDAN, Paris. 1891.

The enlarged and revised edition of Sir J. HERSCHEL's General Catalogue, with additions, published by Dr. DREYER, now of the Armagh Observatory, contains the positions of 7840 nebulas, of which Mr. BIGOURDAN finds that about 6380 are observable at Paris. He estimates that the number of those whose positions have been accurately determined is about 1500, and has proposed to himself the laborious and important task of making precise observations of all the nebulas and clusters visible at the Paris Observatory. The present publication contains the first results of this undertaking, and comprises the nebulas situated between 15^h and 16^h of right-ascension.

The introduction, which is a general one for the whole catalogue, is elaborate and full. It commences with a comprehensive, historical summary of observations of nebulas, or groups having that aspect, from the six mentioned in the Almagest, down to the nearly 8000 known at present. AL-SÛFI, in the tenth century, added three to PTOLEMY's list, — the nebula in *Andromeda*, the cluster containing *F.* 4 and 5 *Vulpeculae*, and the blurred object Lac. 3505 and 3507 just north of *o Velorum*. ULUGH BEG, five centuries later, gave none excepting those in the Almagest; TYCHO BRAHE, 250 years later still, added five more; and HEVEL's *Prodromus* contained sixteen, of which only ten were new. The want of accurate determinations of position might make the absolute identification of some of these difficult, were the objects more numerous; but as the records stand, there is small opportunity for confusion.

Thus 24 appear to have been known before the introduction of the telescope. HALLEY added 2, — that around *ω Centauri* and the brilliant region near *ζ Scorpii*. FLAMSTEED observed 10 more, among them that around *θ Orionis*, discovered by CYSAT in 1618; and yet two more appear to have been known before 1700, making the total number then on record to be less than 40.

The number increased slowly until the middle of the last century, when LACAILLE's southern expedition contributed about 40 to the list, and the numerous searches for telescopic comets yet more. But especially, MECHAIN and MESSIER discovered some 75, which were combined in a single catalogue. Then came the great era of HERSCHEL, who discovered about 2500 within the twenty years beginning with 1783; and later his son made a scrutiny of the southern hemisphere for the purpose of detecting them there. Since about 1850, our knowledge of the nebulas has not been limited to their enumeration and the determination of their approximate position, but great attention has been devoted to their careful measurement by many able observers.

The methods of observation and reduction are described by Mr. BIGOURDAN, with great minuteness. The measurements are made in the form of distances and position-angles, from well-determined stars, these coordinates being subsequently converted into differences of right-ascension and declination for the epoch 1900.0. The details of the observations are fully recorded, as also the power employed, and the mode of setting, together with estimates of the brightness, of the ease of measurement, and of the state of the sky.

Except for the first three months, the telescope employed had an aperture of 32 cm., and a focal length of $5^m.20$, but was slightly diaphragmed, so as to render its practical aperture essentially the same as that employed at the beginning, which was about 15 mm. less.

Mr. BIGOURDAN has nearly completed his work for about ten hours of right-ascension, and intends publishing the results promptly. During his seven years of observations, about one-half of the number of nebulas visible have been already measured, — many of them repeatedly. But since the remainder must be observed at less favorable seasons, he proposes availing himself of photographic methods to some extent in regions where they are especially abundant.

CONTENTS.

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PERIODIC VARIATION OF THE LATITUDE AT CORDOBA.

By B. A. GOULD.

The results obtained by Dr. CHANDLER, showing that the hitherto unexplained anomalies in latitude, determined between 1860 and 1875, could be reconciled by a period of fourteen months, led me to believe that the same phenomenon might be detected in the Cordoba observations. The uniform practice there was to observe three pairs of circumpolar stars on each night when the sky permitted, each pair consisting of one above, and one below, the pole. These were selected from the list of 54 circumpolars, of which the positions are given in the Introduction to vol. V, of the Cordoba Results: and, although the immediate purpose of the observations was to obtain times of transit, which should permit a continued scrutiny of the azimuthal error of the Meridian Circle, the declinations were observed at the same time, whenever possible. The meridian southward was unobstructed to the horizon, traversing an almost uninhabited range of pampa. And although the atmosphere was in general hazy at low altitudes, the observations for declination were systematically maintained upon all the stars of the list, however low at their inferior culmination. In this way I hoped to obtain, not only the most accurate determinations possible for the latitude, and for the declinations of these 54 stars, but also the means of testing, under these exceptional circumstances, BESSEL's values for the vertical refraction at large zenith-distances.

Inasmuch as the several observations for the declinations were in general, averaged in groups of twelve months, while the period of latitude-variation appears to be very nearly fourteen months, it has seemed to me that, by combining the observations of each star in monthly means, the lately discovered phenomenon might be made manifest.

The difficulties in the way of thus detecting a periodic variation, and of determining its amount, will be recognized on reference to the detailed statements given in the Introductions to several of the volumes of the Cordoba Results. The change in position of the instrument, and the partial rotation of its graduated circle, made in every year but one, during the whole series of observations of the zones and for the General Catalogue, embarrass the employment of the results for our present purpose; and a still greater difficulty is presented by the number of different observers who took part in the work. This subject will be found fully discussed in chapter VIII (pp. *clx–clxvii*) of the Introduction to vol. V, already cited.

How far the differences between the various corrections to the provisionally assumed value of the latitude, which are tabulated on page *clxiii*, might be referable to the periodic variations in a cycle of fourteen months, could only be determined by a new discussion, in which these corrections should be deduced in some other way; and the combination of the data in monthly groups seemed most convenient. In effecting this, it has appeared best to take no account of the possible personal differences between observers; which indeed eliminate themselves to a considerable extent, when the same person has observed at both culminations.

Before I left Cordoba, at the end of February 1885, the results of the observations, from their commencement in June 1872 until the end of the year 1884, had been arranged for publication, in the same form as in the volumes of Results already printed. The actual printing, however, had not progressed farther than the middle of the volume for 1874. The publication has since then been carried regularly forward by my successor, Dr. THOME; and the volume for 1880 has been received only since the present investigation was well advanced. Consequently the observations made since that year are not accessible to me here at Cambridge, and it is impossible to extend this examination over a longer period than the 103 months preceding the beginning of 1881.

The pointings made at lower culmination upon stars of comparatively large polar distance were frequently quite unsatisfactory on account of the blurred character of the images. Their results were nevertheless recorded, but the fact of their supposed untrustworthiness was noted by the observer at the time. Such values are indicated in the printed volumes by being inclosed within brackets, although this indication appears to have been unfortunately omitted in the volume for 1880. In the monthly means here given, none of the bracketed observations are included. A few others have also been omitted in forming these means, owing

to discordances so decided as to suggest some error. Of such rejected observations there are 32 in all, and with no marked preponderance for any one observer. They are as follows:

Date	Star	Date	Star	Date	Star
1872 Sept. 28	No. 11 –	1876 May 2	No. 52 β *Octantis*	1879 Dec. 23	No. 11 σ *Octantis*
" 29	15 ζ *Mensae*	1877 Sept. 26	18 α "	1880 Dec. 14	6 –
" 9	16 –	Nov 21	53 τ "	Sept. 7	18 θ *Chamael.*
1873 Oct. 8	22 ν *Chamael.*	1878 June 23	7 ν *Hydri*	Feb. 16	20 ζ *Octantis*
Nov. 16	30 δ *Muscae*	July 30	8 θ "	Nov. 17	29 ι "
Apr. 2	35 δ *Octantis*	Mar. 1	17 –	" 28	36 α *Apodis*
Feb. 12	53 τ "	Nov. 30	32 κ *Octantis*	June 23	40 γ "
1874 Aug. 7	8 θ *Hydri*	" 29	38 ρ "	Jan. 5	42 –
Apr. 28	25 δ₂ *Chamael.*	Aug. 13	39 δ *Apodis*	May 31	52 β *Octantis*
1875 May 20	54 γ *Octantis*	Mar. 16	45 ζ *Pavonis*	Apr. 10	54 γ "
1876 Jan. 12	45 ζ *Pavonis*	1879 Nov. 28	27 –		

In the absence of an exact knowledge of the latitude, all declinations, throughout the 12½ years of meridian observations until the end of 1881, were obtained by employing the provisional value, —31° 25′ 15″.0, known to be smaller than the true one, and they are so printed. After the close of each year the polar point for the circle was deduced from the observations of circumpolars at both culminations made during the year; and the corresponding correction, $\Delta\varphi$, for the assumed latitude is given in the Introduction to each annual volume, — to be numerically added to all declinations, excepting those derived from lower culminations or belonging to northern stars, and to be subtracted from these. The small table already cited (*Results*, V, *clxiii*) shows these values of the correction $\Delta\varphi$, as determined for each observer in each year, together with its annual mean value for all the observers; as well as the general value, applicable to the means of all declinations observed during the year, and also the most probable correction to the provisional latitude 15″.0. The several values of $\Delta\varphi$, given in the different annual volumes, range from 0″.30 to 0″.58, and the final resultant value for the latitude, as deduced in January 1885, is 15″.46.

In the Table now to be given the quantities represent the monthly residuals, C — O, — the negative signs of the latitude and the declinations being disregarded, so that larger positive values represent a higher southern latitude. To obtain them, the quantity 0″.46 was applied to the monthly means of the printed declinations, — additively to those derived from upper, and subtractively to those from lower, culmination. These Observed declinations, already referred to the mean equinox of the beginning of the year, were subtracted from the corresponding Calculated ones, derived from the final discussion in the Introduction to vol. V of the Cordoba Results, and given in the penultimate columns of the respective tables. The mean of the resultant values for all the stars was then taken, using the number of observations as weights. The results from culminations above and below the pole have been treated separately, and these with the half-difference of the two (taken by weights) are also presented. For each of these three classes of results, the total number of observations is prefixed to the mean value derived from the circumpolars observed during the month.

In forming these monthly mean values of the excess of the calculated over the observed declinations, two of the stars, β *Hydri* and π *Mensae*, have been excluded, on account of their large proper motion in declination, which, if allowed for, would entail considerable additional labor, without essentially modifying the result. All observed declinations of the other 52 circumpolars are here included, except the 32 single observations, already specified.

MEAN EXCESS OF THE CALCULATED, ABOVE THE OBSERVED, DECLINATIONS, BY MONTHS.

Date	Upper		Lower		½(U.C.—L.C.)		Date	Upper		Lower		½(U.C.—L.C.)	
		″		″		″			″		″		″
1872 June	11	+0.20	14	—0.12	25	+0.15	1873 June	42	+0.52	42	—1.05	84	+0.78
July	38	— .23	25	— .56	63	+ .08	July	77	+ .52	63	—0.76	110	+ .63
Aug.	21	— .13	20	— .32	41	+ .09	Aug.	70	+ .09	69	— .40	139	+ .24
Sept.	45	— .15	47	— .14	92	— .07	Sept.	37	— .26	30	+ .22	67	— .15
Oct.	44	— .44	52	+ .18	96	— .30	Oct.	14	+ .26	37	— .54	81	+ .39
Nov.	42	— .34	38	+ .07	80	— .21	Nov.	38	— .02	34	— .10	72	+ .04
Dec.	41	— .19	46	— .04	87	— .06	Dec.	56	+ .11	54	— .29	110	+ .20
1873 Jan.	39	+ .25	42	— .17	81	+ .21	1874 Jan.	49	— .09	50	— .56	99	+ .24
Feb.	17	+ .58	20	— .67	37	+ .63	Feb.	25	— .17	34	— .41	59	+ .17
Mar.	8	+0.93	1	— .38	12	+0.75	Mar.	43	+ .15	39	— .52	82	+ .33
Apr.	60	+1.09	73	— .14	133	+1.29	Apr.	46	+ .51	40	— .72	86	+ .60
May	21	+1.07	32	—0.86	53	+0.94	May	25	—0.18	27	+0.02	52	—0.10

Date	Upper	Lower	½ U.C.—L.C.
	″	″	″
1874 June	40 +0.13	34 —0.05	74 +0.10
July	33 — .33	26 + .36	59 — .34
Aug.	44 — .14	43 + .30	87 — .22
Sept.	36 — .35	30 + .19	66 — .28
Oct.	33 — .30	26 — .28	59 — .05
Nov.	39 — .18	35 — .17	74 — .02
Dec.	40 — .20	40 — .20	80 .00
1875 Jan.	32 — .28	28 — .34	60 — .01
Feb.	48 — .05	54 — .26	102 + .11
Mar.	48 + .06	50 — .23	98 + .14
Apr.	62 — .25	54 — .27	116 — .01
May	58 + .15	58 — .39	116 + .27
June	63 + .39	53 — .79	116 + .57
July	68 + .41	60 — .63	128 + .51
Aug.	61 + .10	55 — .01	116 + .06
Sept.	46 — .78	35 + .65	81 — .72
Oct.	46 — .80	40 + .46	86 — .64
Nov.	61 — .56	49 + .80	110 — .67
Dec.	61 — .64	60 + .51	121 — .58
1876 Jan.	56 — .74	56 + .36	112 — .55
Feb.	50 — .63	47 + .70	97 — .66
Mar.	46 —0.90	49 + .62	95 — .76
Apr.	32 —1.10	39 + .51	71 — .78
May	57 —0.55	40 + .03	97 — .34
June	112 — .50	51 — .02	163 — .34
July	73 — .21	33 + .44	106 — .27
Aug.	63 — .34	52 + .25	115 — .29
Sept.	37 —0.08	35 — .01	72 — .03
Oct.	30 —0.17	25 — .04	55 — .07
Nov.	21 — .03	25 + .50	46 — .29
Dec.	32 — .10	35 + .35	67 — .23
1877 Jan.	49 — .21	46 — .12	95 — .05
Feb.	53 — .16	59 + .20	112 — .18
Mar.	26 + .15	40 + .49	66 — .06
Apr.	21 + .41	25 + .04	46 + .16
May	59 — .23	56 + .39	115 — .31
June	36 — .31	30 + .35	66 — .33
July	33 — .44	20 + .35	53 — .20
Aug.	64 — .20	51 + .23	115 — .21
Sept.	44 —0.06	38 +0.16	82 —0.10
1877 Oct.	47 +0.06	48 +0.24	95 —0.09
Nov.	43 + .07	46 + .25	89 — .10
Dec.	39 + .07	44 + .02	83 + .02
1878 Jan.	29 + .64	34 — .13	63 + .38
Feb.	36 + .54	36 — .17	72 + .35
Mar.	33 + .52	37 — .03	70 + .28
Apr.	27 + .60	20 — .47	47 + .53
May	60 + .05	57 — .15	117 + .10
June	42 + .06	32 — .60	74 + .33
July	68 — .04	53 — .07	121 + .01
Aug.	55 — .19	57 + .18	112 — .18
Sept.	60 + .31	48 — .11	108 + .22
Oct.	58 + .21	62 + .08	120 + .06
Nov.	43 + .29	43 — .68	86 + .49
Dec.	55 + .41	46 — .66	101 + .52
1879 Jan.	39 + .03	44 — .15	83 + .09
Feb.	28 — .02	31 — .05	59 + .02
Mar.	42 + .01	43 — .11	85 + .06
Apr.	57 + .02	33 — .25	90 + .14
May	55 + .38	47 — .21	102 + .30
June	48 + .27	41 — .22	89 + .25
July	44 + .15	27 + .07	71 + .04
Aug.	56 + .35	40 — .13	96 + .24
Sept.	60 + .09	43 — .31	103 + .20
Oct.	24 + .19	21 — .32	45 + .25
Nov.	41 + .10	39 — .32	80 + .21
Dec.	33 — .16	43 — .16	76 + .02
1880 Jan.	62 + .09	59 — .29	121 + .19
Feb.	48 — .09	53 — .07	101 — .01
Mar.	52 + .10	63 — .26	115 + .18
Apr.	63 + .31	53 — .38	116 + .34
May	49 + .13	44 — .23	93 + .18
June	51 + .22	35 — .36	86 + .28
July	33 + .06	23 — .21	56 + .12
Aug.	54 — .08	37 + .06	91 — .07
Sept.	51 — .62	47 + .32	98 — .48
Oct.	47 — .39	37 + .24	84 — .33
Nov.	52 — .12	54 — .05	106 — .04
Dec.	58 —0.03	57 +0.01	115 —0.02

Upon charting these results two facts attract attention: first, that the times of maxima and minima of the curve are approximately coincident with those deduced by Dr. CHANDLER from contemporaneous observations in other places, and secondly, that the corresponding periodical fluctuations of the curve are markedly inferior to other and larger variations, upon which they appear superposed. By far the most conspicuous maximum, in the last column, occurs during the second quarter of the year 1878; and the most conspicuous minimum is at the close of 1875 and beginning of 1876. The range included between these extremes amounts to two seconds, and is altogether too large to be attributed either to personal equation or to any instrumental origin. It may be supposed that peculiar influences, connected with the refraction at low altitudes, or due to chilling currents of air from the south, when the shutters at the side of the observing-room were open to permit observations near the horizon, might afford plausible explanations of anomalies at the lower culminations. Such influences undoubtedly do tend to blur the images, and to increase the probable error of observation; yet they would vary but little at the same season in different years. To make this point clearer, the curves have been charted for each culmination separately, as well as for both combined. While these curves do not agree closely, they are in full accord, as regards the principal fluctuations; indeed, the relative smallness of the irregularities, in the curve representing the total results, leads to a belief that the values deduced from the two culminations together are more trustworthy than those from either alone.

If, in our computation, the latitude-correction, l_c, as derived from the observations of any one year, had been employed for determining the declinations of that year, instead of the general value 0″.46, employed for all years, the curve would not have been essentially different. The corresponding quantities C − O can readily be obtained from the foregoing table, by adding to all the monthly results the excess of the l_c, for that year, above the general value. Thus all the monthly means for the year 1872 would be-

creased by 0″.08, all those for 1873 increased by the same amount, etc.

Moreover if, instead of obtaining these monthly means by a combination of the values of C — O which result from all the stars, in each month, we take the mean of all those afforded by each star during the whole period of 103 months, — assigning equal weight to the several monthly means, but keeping the results from each culmination separate, — we may deduce from the observations of each star a correction to the adopted latitude, and another to the calculated declination. It might seem that by the use of these values, in place of the Calculated declinations taken from the tables, a better series of results might be obtained; since we should be dealing with the variations of the observed declination from their own mean, and any possible errors in the calculated values would be thus eliminated. In this way the values C — O would be modified by a constant quantity for each star; and, after this modification, the monthly means from all the stars could be formed as before.

This somewhat laborious process has been performed, and the whole computation repeated in this way. The resultant curve resembles the original one so closely as to make it evident that no improvement is to be attained by this process; in fact, the unimportant differences between the two give indication that the former is the better, since it is somewhat less irregular, as might have been expected on account of the more symmetric distribution of the data. It is scarcely worth the space, to print the later series of results; yet, to enable any inquirer to make the comparison for himself, those values are appended which have been deduced in this way from the combination of observations at both culminations.

RESIDUALS (C—O). — OBSERVED DECLINATIONS REFERRED TO THEIR OWN MEAN.

Values of ½ (U.C. — L.C.) for Monthly Means.

			″				″				″				″
1872	June	25	—0.04	1874	Aug.	87	—0.20	1876	Oct.	55	+0.04	1878	Dec.	101	+0.63
	July	63	+ .01		Sept.	66	— .23		Nov.	16	— .22	1879	Jan.	83	+ .09
	Aug.	44	+ .07		Oct.	59	+ .05		Dec.	67	— .17		Feb.	59	.00
	Sept.	92	+ .04		Nov.	74	+ .05	1877	Jan.	95	— .05		Mar.	85	+ .07
	Oct.	96	— .20		Dec.	80	+ .06		Feb.	112	— .19		Apr.	90	+ .04
	Nov.	80	— .09	1875	Jan.	60	— .03		Mar.	66	— .09		May	102	+ .22
	Dec.	87	— .04		Feb.	102	+ .14		Apr.	46	+ .04		June	89	+ .15
1873	Jan.	81	+ .22		Mar.	98	+ .14		May	115	— .40		July	71	+ .01
	Feb.	37	+0.60		Apr.	116	— .12		June	66	— .45		Aug.	96	+ .24
	Mar.	12	+1.60		May	116	+ .16		July	53	— .26		Sept.	103	+ .25
	Apr.	133	+1.48		June	116	+ .14		Aug.	115	— .24		Oct.	45	+ .36
	May	53	+0.82		July	128	+ .43		Sept.	82	— .08		Nov.	80	+ .31
	June	81	+ .68		Aug.	116	+ .06		Oct.	95	+ .02		Dec.	76	+ .11
	July	140	+ .59		Sept.	81	— .71		Nov.	89	.00	1880	Jan.	121	+ .19
	Aug.	139	+ .25		Oct.	86	— .53		Dec.	83	+ .10		Feb.	101	— .01
	Sept.	67	— .12		Nov.	110	— .52	1878	Jan.	63	+ .36		Mar.	115	+ .14
	Oct.	81	+ .18		Dec.	124	— .48		Feb.	72	+ .33		Apr.	116	+ .26
	Nov.	72	+ .18	1876	Jan.	112	— .53		Mar.	70	+ .19		May	93	+ .03
	Dec.	110	+ .28		Feb.	97	— .67		Apr.	47	+ .45		June	86	+ .19
1874	Jan.	99	+ .27		Mar.	95	— .79		May	117	+ .01		July	56	+ .07
	Feb.	59	+ .31		Apr.	71	— .88		June	74	+ .20		Aug.	91	— .06
	Mar.	82	+ .26		May	97	— .46		July	121	— .03		Sept.	98	— .42
	Apr.	86	+ .51		June	163	— .44		Aug.	112	— .16		Oct.	84	— .21
	May	52	— .13		July	106	— .33		Sept.	108	+ .28		Nov.	106	+ .08
	June	71	— .02		Aug.	115	— .30		Oct.	120	+ .14		Dec.	115	+0.03
	July	59	—0.16		Sept.	72	+0.02		Nov.	86	+0.60				

The corrections to the calculated declinations (in the Introduction to vol. V) which result from the Cordoba observations, and by use of which the foregoing table was prepared, are themselves not without instructiveness. These corrections are entitled to far less confidence than are the elaborately deduced "calculated values," to which they are applicable, — both because the observations upon which they depend are so much fewer, and because the final means have been obtained by assigning equal weight to the several monthly means, regardless of the corresponding number of observations. Still the character of these resultant values deserves investigation.

The following table contains the data in question. It exhibits the mean monthly values of C — O for each of the 54 stars, at each culmination, derived from all the observations during the 103 months from June 1872 to December 1880. The means, given with their respective weights in the last two columns, represent quantities to be subtracted from the adopted "calculated" declinations.

DECLINATIONS OF CIRCUMPOLAR STARS OBSERVED AT CORDOBA.

Means of Monthly Values of C.—O. for each Culmination and Resultant Corrections.

	Star	U. C.		L. C.		Mean	Wt.
			"		"	"	
1	γ_3 *Octantis*	25	—0.260	23	—0.587	—0.424	12
2	o "	7	— .363	7	+ .123	— .120	4
3	β *Hydri*	17	— .027	19	— .051	— .040	9
4	λ "	24	+ .053	26	— .099	— .023	12
5		25	— .059	28	— .116	— .102	13
6		19	— .111	26	— .459	— .285	11
7	μ *Hydri*	28	— .232	28	— .250	— .241	11
8	θ "	23	+ .087	24	— .024	+ .032	12
9		22	+ .315	22	— .256	+ .030	11
10	γ *Hydri*	19	— .160	22	— .379	— .270	10
11		27	+ .078	21	— .225	— .074	12
12	η *Mensae*	21	— .019	27	— .007	— .013	12
13	ξ "	31	+ .017	23	— .237	— .110	13
14	π "	30	+ .158	27	+ .220	+ .189	14
15	ζ "	30	+ .067	31	— .275	— .101	15
16	γ *Volantis*	10	— .562	12	+ .705	+ .072	5
17		29	+ .017	31	+ .042	+ .030	15
18	θ *Chamael.*	36	— .059	26	— .114	— .086	15
19	β *Carinae*	14	— .112	11	+ .310	+ .099	6
20	ζ *Octantis*	29	+ .072	20	— .247	— .088	12
21	ζ *Chamael.*	29	+ .157	28	+ .059	+ .108	14
22	μ "	20	— .072	20	+ .056	— .008	10
23	ω *Carinae*	11	— .085	7	— .014	— .050	4
24	*I* "	23	— .040	11	— .020	— .030	7
25	δ_2 *Chamael.*	25	+ .239	27	— .051	+ .094	13
26	η *Octantis*	27	+ .364	19	— .063	+ .150	11
27		28	+0.234	28	+0.115	+0.190	11
28	β *Chamael.*	24	—0.023	21	+0.0[illegible]6	+[illegible]	12
29	ι *Octantis*	27	+ .264	20	+ .045	+ .155	12
30	δ *Muscae*	14	— .072	17	+ .327	+ .128	8
31		9	— .411	12	— .146	— .278	5
32	κ *Octantis*	26	+ .251	24	— .006	+ .122	12
33	θ *Apodis*	26	+ .176	16	+ .089	+ .132	10
34	η "	17	+ .219	15	+ .262	+ .240	8
35	δ *Octantis*	21	— .120	10	+ .096	— .012	7
36	α *Apodis*	21	+ .059	12	— .065	— .003	8
37	π *Octantis*	14	+ .077	26	— .213	— .068	9
38	ρ "	29	+ .252	27	— .301	— .024	14
39	δ_1 *Apodis*	26	+ .025	27	— .467	— .221	13
40	γ "	24	+ .225	21	— .227	— .001	11
41	α *Triang. A.*	21	— .320	19	+ .201	— .060	10
42		26	+ .004	27	— .231	— .115	13
43	χ *Octantis*	27	+ .101	28	+ .161	+ .132	14
44	σ "	18	+ .049	19	+ .201	+ .125	9
45	ζ *Pavonis*	26	— .077	21	— .059	— .068	12
46		32	+ .078	26	— .223	— .072	14
47		30	— .048	29	— .187	— .118	15
48	α *Octantis*	28	+ .031	37	— .061	— .016	16
49	*B* "	9	— .103	14	+ .076	— .014	6
50	λ_1 "	32	+ .021	34	— .213	— .096	10
51	ν "	24	— .210	31	— .115	— .162	14
52	β "	26	— .018	30	— .181	— .250	14
53	τ "	22	— .070	25	— .633	— .352	12
54	γ_1 "	26	—0.291	28	—0.361	—0.328	13

If these quantities, $I\delta$, be combined for each hour of right-ascension, and charted, the existence of a term dependent upon the right-ascension becomes conspicuous. This term may be approximately represented by the expression $-0''.052 + 0''.118 \sin(\alpha + 18^{h})$. It might be plausibly explained by the influence of the periodic variation of fourteen months' period in the earlier observations from which the proper motions were deduced, since this must necessarily affect the calculated declinations, employed in forming the residual C—O, and act as a function of the right-ascension. Or, it might be supposed that a slight error exists in the constant of aberration employed for reducing the observed declinations from apparent to mean positions. In order to determine the value of this term, free from the effect of any periodic variation of the latitude during the continuance of the observations, the table, just given, was constructed anew, using only the results from 1874 January to 1880 December. These seven consecutive years comprise six full periods, so that the effect upon the term in question, produced by any systematic variation in the observed declinations, is necessarily eliminated, whether its period be twelve months or fourteen. The variation dependent upon the right-ascension, as deduced from this somewhat smaller series, is not very different from the previous value, being approximately expressed by

$$-0''.038 + 0''.075 \sin(\alpha + 18^{h}).$$

Considering next the corresponding values for $I\pi$, deducible from the half differences of the mean values of C—O in the table, no systematic variation dependent upon the right-ascension is recognizable in them; but when they are arranged according to the polar distances of the stars, the case is somewhat otherwise. For while, here also, no regular variation depending upon the declination is to be perceived for polar distances less than 13°, the values of C—O grow decidedly, although slightly, smaller for declinations smaller than 77°. It would be natural to attribute this to a refraction near the horizon somewhat greater than is given by Bessel's constant; but such interpretation is excluded by a nearer examination, inasmuch as the discordance is essentially the same at each culmination.

These facts are easily recognizable upon inspection of the following tables, which are formed from the total of the observations made during the seven years beginning with 1874. The first shows for each star the half difference of the mean values of C.—O. as derived from the two culminations during these seven years.

CORDOBA LATITUDE-CORRECTIONS, ($\Delta\varsigma$).

Half-Excess of C. — O. at Upper Culmination.

		Decl.	$\Delta\varsigma$	Wt.			Decl.	$\Delta\varsigma$	Wt.			Decl.	$\Delta\varsigma$	Wt.
		° ′	″				° ′	″				° ′	″	
1	*γ Octantis*	82 55	+0.037	10	19	*β Carinae*	69 12	—0.241	6	37	*π Octantis*	82 32	+0.096	7
2	*ο* "	89 4	.255	2	20	*ζ Octantis*	85 10	+ .112	8	38	*ρ* "	84 3	+ .229	11
3	*β Hydri*	77 58	+ .012	7	21	*ζ Chamael.*	80 22	— .044	12	39	*δ₁ Apodis*	78 23	— .026	10
4	*λ* "	75 36	— .072	10	22	*η* "	84 37	— .186	8	40	*γ* "	78 37	+ .107	8
5		79 8	— .012	10	23	*ω Carinae*	69 25	— .111	4	41	*α Tri. Austr.*	68 18	— .200	8
6		85 21	+ .129	9	24	*I* "	73 24	— .082	6	42		80 44	+ .076	11
7	*ν Hydri*	79 39	— .008	11	25	*δ₂ Chamael.*	79 53	+ .118	11	43	*λ Octantis*	87 39	— .132	11
8	*θ* "	72 23	— .029	10	26	*η Octantis*	83 55	+ .116	9	44	*σ* "	89 17	— .218	7
9		78 46	+ .115	8	27		81 56	— .030	11	45	*ζ Pavonis*	71 32	— .112	9
10	*γ Hydri*	74 37	— .086	8	28	*β Chamael.*	78 37	— .172	9	46		82 0	+ .090	12
11		83 10	+ .120	9	29	*ι Octantis*	84 27	+ .108	9	47		83 42	+ .090	12
12	*η Mensae*	75 8	+ .012	10	30	*δ Muscae*	70 52	— .228	7	48	*α Octantis*	77 30	— .080	13
13	*ξ* "	82 38	+ .084	10	31		85 14	— .262	4	49	*B* "	89 25	+ .070	4
14	*π* "	80 34	— .154	11	32	*κ Octantis*	85 9	+ .119	10	50	*λ₁* "	83 17	+ .091	14
15	*ζ* "	80 44	+ .033	12	33	*θ Apodis*	76 11	+ .022	8	51	*η* "	86 36	— .116	12
16	*γ₂ Volantis*	70 18	— .673	5	34	*η* "	80 25	— .130	6	52	*β* "	82 2	+ .180	12
17		86 49	+ .038	12	35	*δ Octantis*	83 6	— .160	5	53	*τ* "	88 10	+ .100	9
18	*θ Chamael.*	77 5	—0.068	12	36	*α Apodis*	78 34	—0.080	6	54	*γ₁* "	82 43	+0.035	11

The second gives the mean of the same quantities when combined, according to the declination of the stars, in groups of 2° each. The observations of *γ₂ Volantis* are omitted, in consequence of this star's large deviation from its calculated position, — a subject to be considered at another time.

The values of $\Delta\varsigma$ are the mean values of all the half-differences for the several stars of the respective groups, combined by weights depending on the number of months in which they were observed. Those of C. — O. given for each culmination, were obtained by using the same weight for each star, without regard to the number of months of observation.

MEAN VALUES OF LATITUDE-CORRECTIONS, ACCORDING TO DECLINATION OF THE STARS.

Decl.	Mean	No. obs.	$\Delta\phi$	Wt.	C — O U. C.	C — O L. C.
° °	° ′		″		″	″
89,88	88 50	311	—0.038	22	—0.233	—0.113
87.86	87 0	620	— .067	35	— .095	+ .032
85,84	84 54	960	+ .086	62	+ .114	— .098
83,82	82 54	1784	+ .095	111	— .024	— .195
81,80	80 12	989	— .054	60	— .005	+ .074
79,78	79 1	1023	+0.009	73	—0.041	—0.069
77,76	77 12	806	—0.040	40	—0.060	+0.009
75,74	75 9	134	— .046	28	— .017	+ .079
73,72	72 46	293	— .049	16	— .022	+ .085
71,70	71 12	241	— .163	16	— .083	+ .251
69,68	69 4	259	—0.181	18	—0.164	+0.199

(Concluded in next number.)

NOTE ON SECULAR VARIATION OF LATITUDE.

BY S. C. CHANDLER.

I am very reluctant to say any more on this topic, but do not see how I can, with courtesy, avoid answering Prof. COMSTOCK's two earnest requests: first, that I present good reasons for not rejecting the Washington reflection-observations — the answer to which is that I did reject them: secondly, that, "as a matter of simple justice" I should amend my statement so that it may read, "the presumed (secular) variation depends upon observations at Washington, Cambridge and Madison, which are in substantial agreement both as to magnitude and direction of motion." The meaning of this is not quite clear. If a difference of opinion exists between A and B as to a matter of fact, it is hard to see how "simple justice" requires A to adopt B's view, any more than it requires B to adopt A's. If Prof. COMSTOCK's meaning is that the force of his new arguments is so great that they settle the matter, and that this fact ought to be publicly acknowledged, his request is intelligible; but it is inadmissible, because he appears to be mistaken on the following points:

1. In stating that I rejected *β Persei* for discordance merely. The real reason he will find in nos. 255 and 256. Until we know more about the irregularity in the proper motion, the star is disqualified for any fundamental use.

2. In throwing out the asymmetric prime-vertical observations of 1844,5, thus erroneously diminishing the latitude.

3. In correcting AUWERS's declination of *γ Andromedae* by —0″.28 with a similar effect.

4. It is inconsistent to admit doubt as to BRADLEY's latitude and, *at the same time*, to accept without question, as

evidence of change of latitude merely, a difference between other latitude-determinations based on AUWERS's proper motions, which rest on BRADLEY as absolute.

5. ROGERS's determination in 1864 was made when the fourteen-months' variation was near a maximum.

6. For the above reasons, even a much larger difference than Prof. COMSTOCK finds (0″.5) between the two Cambridge prime-vertical values would melt away.

7. The foregoing presents a better illustration than I could have invented of the truth which Prof. COMSTOCK calls my "most serious error of all," namely, the remark that "it is premature to speculate upon the secular variation until the laws of the periodic variation are more fully understood."

8. Prof. COMSTOCK dismisses the Washington transit-circle observations because "it does not seem profitable to spend much time upon their discussion." I have spent a good deal of time on them, and hope that the results when printed will show that it has not been wasted, and that we can infer from them something of more significance than that "the latitude has probably not changed more than three or four seconds."

The above points seem to provide answers to Prof. COMSTOCK's questions. Of course I cheerfully admit that the Washington prime-vertical observations of 1845-9 and 1882-4 support his hypothesis, albeit it is support which it could well afford to do without. I would most gladly have made this exception in his favor, explicitly, before, but did not feel sure that he would be pleased. And here one word as to his lively and easily aroused sympathy for the Naval Officers. I neither made nor intended any reflection whatever on their capacity. Capacity is not in question, but skill and experience. The astronomical work of a naval officer who has these in a sufficient degree to make good prime-vertical observations, and to reduce them correctly, is entitled to the same respectful treatment as any other. But there are many professional astronomers who would feel, and willingly admit, a good deal of diffidence in their own ability to avoid successfully the pitfalls which beset this technical class of work. I, for one, freely acknowledge that I should undertake it with some trepidation. I should equally distrust the results obtained by any one else, not having special training for it, whether naval officer or not, and should not be surprised at his unearthing some such peculiar phenomenon as has apparently been turned up by these observations in question. I furthermore do not believe that any sensible naval officer can take offence at honest distrust of the sort, although he may think it unreasonable and prejudiced.

In conclusion, Prof. COMSTOCK will find it of interest to examine, in the light of his hypothesis, Prof. DOOLITTLE's work on latitudes, which appears to me the most valuable contribution on this subject which has yet appeared. It satisfies the most exacting requirements as to homogeneity, being the result of one observer's continued work, using the same instrument, method, and stars. The curious differences between the 1877 and 1886 results (see this Journal, VII, 11) we may now certainly trace to the fourteen-months' variation, and the later ones, 1888 and 1890, will probably prove equally amenable, when I have finally determined the law of increase in the period, on which I am now at work, with the end in sight. Prof. DOOLITTLE's series appears to contradict Prof. COMSTOCK's hypothesis quite as plainly as do Cambridge, Melbourne and the Washington transit-circle. The testimony of this last is also corroborated by that of the mural-circle values, obtained by Prof. COFFIN in 1846 (39″.23) and Prof. NEWCOMB in 1865 (38″.78).

OBSERVATIONS OF THE PERIODIC COMET OF WOLF (*b* 1891),

MADE AT THE OBSERVATORY OF THE STATE UNIVERSITY, COLUMBIA, MO., WITH THE 7½-INCH EQUATORIAL

BY MILTON UPDEGRAFF.

1891 Columbia M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
d h m s			m s	′ ″	h m s	° ′ ″		
Sept. 29 15 30 46.1	1	13	−2 27.98	−1 57.79	4 25 13.84	+14 32 7.1	*n*8.5950	0.5508
Oct. 1 16 0 56.1	2	9	+3 7.25	+1 21.98	4 27 38.55	+13 33 15.8	8.5367	0.5759
4 16 12 51.3	3	8	−3 8.41	+1 57.83	4 30 53.06	+12 1 9.1	8.8809	0.6007
9 11 39 55.4	4	9	−1 2.14	+5 3.68	4 35 17.12	+9 30 50.6	*n*8.9147	0.6371
11 14 12 15.3	5	8	+1 21.70	−1 51.89	4 36 11.14	+8 26 51.2	*n*8.8618	0.6503

Mean Places for 1891.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority	1891	O – C	
	h m s	s	° ′ ″	″				
1	4 27 39.67	+2.15	+11 36 52.6	+12.27	Glasgow Catalogue	Sept. 29	+2.29	−16.3
2	4 21 29.10	+2.20	+13 29 11.0	+12.82	" "	Oct. 1	+2.28	−14.9
3	4 33 59.26	+2.21	+11 58 58.6	+12.89	½(Yarnall + Glasgow)	4	+2.26	11.0
4	4 36 16.93	+2.33	+9 25 33.3	+13.57	Glasgow Catalogue	9	+2.63	−33.0
5	4 32 20.05	+2.39	+8 28 32.0	+11.07	" "	11	+2.62	−34.5

The residuals in the last column are obtained by comparison of the observed places with the ephemeris in *A. N.* No. 3054.

THE NEW STAR IN AURIGA.

Comparatively few new observations of this star have as yet been received, the weather having been exceptionally unfavorable during the last three weeks.

Mr. SAWYER writes that he has been prevented by illness from observing it, excepting on the nights of Feb. 16 and 18. On the former he estimated it as just equal in brightness to DM. 30°898 = Lal. 10143, and three steps fainter than DM. 30°869 = W. Bessel V, 331. On Feb. 18 he found that the star had increased by about half a magnitude, being five steps brighter than Lal. 10143, four brighter than *F.* 26 *Aurigae*, and five fainter than χ. From careful determinations in an unpublished catalogue of the magnitudes of the comparison-stars, adjusted to ARGELANDER's scale, their brightness is: χ *Aurigae*, $4^{\mathrm{M}}.9$; *F.* 26 and DM. 30°869, each $5^{\mathrm{M}}.8$; Lal. 10143, $5^{\mathrm{M}}.9$. Hence that of the new star was $6^{\mathrm{M}}.0$ on Feb. 16, and $5^{\mathrm{M}}.4$ on Feb. 18.

Mr. YENDELL has obtained seven observations of the star on six nights from Feb. 9 to Feb. 22. The estimated magnitudes varied from $6^{\mathrm{M}}.0$ to $6^{\mathrm{M}}.4$ during this period, but want of space compels the postponement of the individual observations until the next number of the Journal. The star appeared to him of a bright bluish white color with no tinge of redness.

The *Astr. Nachrichten*, no. 3076, contains the following information, additional to that given in this Journal, no. 255.

At Bonn, Feb. 2, Prof. KUSTNER made a careful comparison of the magnitude with that of three neighboring stars. He estimated it as half a magnitude fainter than χ *Aurigae*; little, if any brighter than *F.* 11; and decidedly brighter than *F.* 26; the resulting magnitude being thus $5^{\mathrm{M}}.5$. Prof. DEICHMÜLLER observed the star on the meridian, and obtained the position, for 1892.0, $\alpha = 5^{\mathrm{h}}\ 25^{\mathrm{m}}\ 3^{\mathrm{s}}.4$, $\delta = +30^\circ\ 21'\ 19''.3$.

The region had been examined for the Bonn *Durchmusterung*, by SCHONFELD, 1856 March 26, and KRUEGER, 1857 Feb. 16. Also again by KRUEGER in the revision-zone 1858 March 23, on which date he observed a star $9^{\mathrm{M}}.5$, distant from the place of the new one by $2^{\mathrm{s}}.5$ and $0'.8$. This faint star has now been observed anew, at Bonn and Hamburg.

At Upsala, Prof. DUNÉR determined its position on Feb. 2, estimated its magnitude as $5^{\mathrm{M}}.5$, and noted its color as yellow. On inspection of the spectrum, although with inadequate apparatus, a very bright line was easily seen at the red end, and another in the blue-green, which he supposed to be probably the hydrogen-lines *C* and *F*. On Feb. 3 the star was almost as bright as χ *Aurigae*, *i.e.* about $5^{\mathrm{M}}.0$; but on the next night it appeared decidedly fainter than χ.

At Turin, Prof. PORRO estimated the brightness, Feb. 3, as notably superior to that of χ.

At Kiel, Mr. F. KROEGER observed the spectrum, Feb. 2, and referred it to VOGEL's type II *b*. It was brilliant and well visible through all the colors from the red to far within the violet, which was very bright and extended. There was a broad black band near *C*. In the red and orange were three groups of lines, separated by equal intervals, and of nearly equal width and intensity, all tolerably wide, but faint. A bright orange line was recognizable near the outer limit of the third group. In the green were numerous dark lines, which increased in breadth and depth toward the blue. A very broad black band was near the limit of the blue-green, blurred on the more refrangible side. Two other broad bands of similar character were visible in the violet, the broader lying nearer to the green. H_γ was not visible as a bright line. The star's color was a dark straw-yellow, and its magnitude $4^{\mathrm{M}}.7$.

On Feb. 4 and 6 the sky was less transparent, and the star appeared decidedly brighter than χ; on the 6th its color was orange.

NEW ASTEROID.

A planet of the eleventh magnitude was discovered by PALISA, at Vienna, February 25, and observed as follows:

1892 Febr. 25.5454 Greenw. M.T. $\alpha = 10^{\mathrm{h}}\ 26^{\mathrm{m}}\ 17^{\mathrm{s}}.4$, $\delta = +7^\circ\ 40'\ 35''$. Daily motion, -56^{s} in α, and 3′ northward.

This, if it prove not to have been previously seen, will bear the number 325; preceding ones being numbered as follows:

319	CHARLOIS	1891 Oct. 8	321	PALISA	1891 Oct. 15	323	WOLF	1891 Dec. 22
320	PALISA	Oct. 11	322	BORRELLY	Nov. 27	324	"	1892 Jan. 20

The name *Constantia* has been given to no. 315.

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PERIODIC VARIATION OF THE LATITUDE AT CORDOBA,

By B. A. GOULD.

Continued from page 134.

Before examining whether the periodic variation of 427 days is manifested by the Cordoba observations, we will inquire into the existence of any annual variation according to cyclical law. For this purpose the mean values of C. — O. for the declinations observed in each month, during the 103 months of observations here considered, are presented in tabular form, together with means of these values according to the number of observations upon which they respectively depend. In forming these last, however, only the values for the seven years, 1874–1880, were employed, in order to eliminate the effect of the periodic variation. The first nineteen months were omitted, rather than the last nineteen, on account of the apparently abnormal maximum in the early part of the year 1873. The monthly means are those of the first table in this article, obtained from all the observations, at both culminations, reduced by using the latitude 31° 25′ 15″.46.

Declinations of Circumpolars (Calc. — Obs.).

	1872		1873		1874		1875		1876		1877		1878		1879		1880		7 Year Mean	
												″								
Jan.	. .	. .	81	+0.211	99	+0.228	60	—0.006	112	—0.549	95	—0.054	63	+0.364	83	+0.089	121	+0.187	633	+0.015
Feb.	. .	. .	37	+ .627	59	+ .168	102	+ .111	97	.664	112	— .182	72	+ .354	59	+ .018	101	— .010	602	—0.063
March	. .	. .	12	+0.748	82	+ .326	98	+ .144	95	— .755	66	— .059	70	+ .261	85	+ .090	117	+ .132	613	+0.022
April	. .	. .	133	+1.287	86	+ .605	116	— .010	71	.778	46	+ .165	47	+ .546	90	+ .106	116	+ .340	572	+0.136
May	. .	. .	53	+0.943	52	— .095	116	+ .269	97	— .336	115	— .306	117	+ .098	102	+ .304	93	+ .176	692	+0.025
June	25	+0.152	84	+ .785	74	+ .096	116	+ .571	163	.341	66	— .326	74	+ .292	89	+ .248	86	+ .278	668	+0.096
July	63	+ .083	140	+ .628	59	— .342	128	+ .511	106	— .274	53	— .201	121	+ .008	71	+ .067	56	+ .118	594	+0.064
Aug.	41	+ .093	139	+ .245	87	— .217	116	+ .055	115	— .286	115	— .211	112	.186	96	+ .257	91	— .074	732	—0.099
Sept.	92	— .068	67	— .154	66	— .278	81	— .724	72	.034	82	— .102	108	+ .225	103	+ .195	98	— .477	610	—0.168
Oct.	96	— .303	81	+ .387	59	— .046	86	— .639	55	.074	95	— .093	120	+ .057	45	+ .248	84	.326	544	—0.147
Nov.	80	— .214	72	+ .037	74	— .017	110	— .667	46	.290	89	.096	86	+ .486	80	+ .207	106	.035	591	0.071
Dec.	87	—0.065	110	+0.201	80	—0.004	121	—0.576	67	0.231	83	+0.020	101	+0.524	76	+0.022	115	0.024	643	0.049

The decided annual variation, exhibited in the final column of mean values for the several months, cannot be overlooked, whatever the influence to which it may be referable. In the absence of any indication as to its origin, it may be attributed to instrumental causes, or to terrestrial ones. The phenomenon is apparently the same as that already recognized when the values of $D\delta$, deduced for the several stars, are arranged in the order of the right-ascensions of these. The fact that the extremes of variation occur in the spring and autumn is unfavorable to the hypothesis that it is connected with the temperature. The variation may be approximately represented by the formula $-0''.020 + 0''.101 \sin(30° m + 321°)$, in which m denotes the number of the month, beginning with January as the first.

The degree of accord between the formula and the mean values for the several months, as shown in the foregoing table, is sufficient to remove any token of system from the residual differences. We have, namely,

	Observation	Formula	O — F
January	+0.015	—0.036	+0.051
February	— .063	+ .017	— .080
March	+ .022	+ .059	— .037
April	+ .136	+ .088	+ .048
May	+ .025	+ .075	— .050
June	+ .096	+ .044	+ .052
July	+ .064	— .004	+ .068
August	— .099	— .057	— .042
September	— .168	.099	— .069
October	— .147	— .128	— .019
November	— .071	— .115	+ .044
December	—0.049	—0.084	+0.035
Time	—0.239	—0.240	— 0.001

The amount of annual variation indicated by this

should evidently be removed from the individual monthly means, before we proceed to test the evidence which they may contain, regarding the latitude-variation which Dr. Chandler has shown to exist at other places.

Subtracting, then, from the several monthly means already at hand, these small amounts corresponding to the annual variation for the same month, we obtain the values arranged below in groups of 14 months each. The means of these groups are taken without regard to the number of observations.

Monthly Means of C. — O. in Declination, freed from Annual Variation.

Arranged in Groups of Fourteen Months Each.

Months	1872 June to 1873 July	1873 Aug. to 1874 Sept.	1874 Oct. to 1875 Nov.	1875 Dec. to 1877 Jan.	1877 Feb. to 1878 Mar.	1878 Apr. to 1879 May	1879 June to 1880 July	1880 Aug. to 1880 Dec.
	″	″	″	″	″	″	″	″
I	+0.108	+0.302	+0.082	—0.492	—0.199	+0.158	+0.204	—0.017
II	+ .087	— .055	+ .098	— .513	— .118	+ .023	+ .071	— .378
III	+ .159	+ .515	+ .080	— .681	+ .077	+ .218	+ .314	— .198
IV	+ .031	+ .152	+ .030	— .814	— .381	+ .012	+ .291	+ .080
V	— .175	+ .288	+ .094	— .866	— .370	— .129	+ .376	+0.063
VI	— .099	+ .274	+ .085	— .111	— .197	+ .321	+ .322	
VII	+ .019	+ .151	— .098	— .385	— .151	+ .185	+ .106	
VIII	+ .247	+ .267	+ .191	— .270	— .003	+ .601	+ .223	
IX	+ .610	+ .517	+ .527	— .229	+ .035	+ .608	— .027	
X	+0.689	— .170	+ .515	+ .065	+ .019	+ .125	+ .133	
XI	+1.199	+ .052	+ .112	+ .051	+ .104	+ .001	+ .252	
XII	+0.868	— .337	— .625	— .175	+ .100	+ .031	+ .101	
XIII	+ .711	— .160	— .511	— .147	+ .337	+ .018	+ .234	
XIV	+0.632	—0.179	—0.552	—0.018	+0.202	+0.229	+0.122	
Mean	+0.365	+0.115½	+0.002	—0.349	—0.018	+0.195	+0.195	

Excesses above the Mean Value, for each Group.

								Mean
		″	″	″		″	″	″
I	—0.257	+0.186	+0.080	—0.143	—0.181	+0.263	+0.009	—0.01
II	— .278	— .170	+ .096	— .161	— .100	— .172	— .121	— .13
III	— .215	+ .400	+ .078	— .332	+ .095	+ .053	+ .119	+ .03
IV	— .334	+ .036	+ .028	— .465	— .363	— .183	+ .099	— .17
V	— .510	+ .172	+ 092	— .517	— .352	— .324	+ .181	— .13
VI	— .461	+ .158	+ .083	— .062	— .179	+ .129	+ .127	— .08
VII	— .346	+ .036	— .100	— .036	— .136	— .010	— .089	— .10
VIII	— .118	+ .152	+ .192	+ .079	+ .015	+ .106	+ .028	+ .11
IX	+ .215	+ .402	+ .525	+ .120	+ .053	+ .113	— .222	+ .22
X	+ .324	— .286	+ .513	+ .414	+ .037	— .070	— .062	+ .12
XI	+ .834	— .064	+ .110	+ .403	+ .122	— .191	+ .057	+ .18
XII	+ .503	— .452	— .627	+ .171	+ .118	— .161	— .091	— .04
XIII	+ .376	— .276	— .513	+ .202	+ .355	— .177	+ .039	.00
XIV	+0.267	—0.294	—0.551	+0.331	+0.220	+0.034	—0.073	—0.01

The first and fourth of these groups exhibit the periodic variation conspicuously, and in accordance with the law indicated by Chandler. So, too, does the fifth, although in a less degree; but the same cannot be said of the other four. No supposition is admissible, that the means of so many careful observations are affected by casual errors to such an extent as these residuals would imply; and the manifest tokens of cyclical law, shown by the series of mean values for the groups, indicate that the results require more elaborate study.

Inasmuch as the purpose of this article is not to determine the laws of the periodic variation, but solely to provide additional data for the investigation of this curious and evidently complex phenomenon, I do not enter upon any thorough discussion of it. It suffices to say that careful inspection has convinced me

1) That Chandler's periodic variation, of about fourteen months, is clearly manifest in the Cordoba observations;

2) That the manifestations fluctuate so irregularly, during the 103 months here considered, that we are compelled to assume that the effect of some other variation is superposed;

3) That both the period and the amplitude of Chandler's variation fluctuated considerably within short intervals;

4) That the monthly means are inadequate to exhibit the phenomena with sufficient exactitude. Semi-monthly means should be employed, at the least, if not ten-day means.

The circumstance, that the same stars could not be observed at both culminations in the same month, must be obviated so far as possible by the employment of a large number of stars, if deductions are to be drawn from a combination of observations above and below the pole; else the inferences can be only roughly approximate.

In the second of the pair of tables, just given, the mean value for each group of fourteen months has been subtracted from the several monthly values forming the group, in order to make the character of the variation during the fourteen months more conspicuous. Not only do three, at least, out of the seven groups, show periodic variations entirely analogous to those expressed by CHANDLER's formula in no. 249 (p. 70) of this Journal, but the same is clearly recognizable in the mean of all, — which, however, necessarily exhibits a smaller amplitude and some little discordance in the epochs of maxima and minima.

Yet a slight modification of the arrangement of the groups, although assuredly not the best that could be made, suffices to show grounds for the conviction, already expressed, that the period was not constant during the eight years through which these observations extended. For, if the first group be reduced to 13 months, and the fourth increased to 15, by transferring July 1873 to the second group, the last month of the second to the third, and the last of the third to the fourth, the periodic variation becomes yet more distinct, while the epochs of maxima and minima in the several groups show a better correspondence. The following table, analogous to the second of those given above, shows the effect of this modification. The means of the several groups, after this rearrangement, are placed at the head of their respective columns. With 15-day means, the results would be still more accordant.

MODIFIED GROUPS. — EXCESSES ABOVE THE MEAN VALUES FOR EACH GROUP.

Months	1872 June to 1873 June	1873 July to 1874 Aug.	1874 Sept. to 1875 Oct.	1875 Nov. to 1877 Jan.	1877 Feb. to 1878 Mar.	1878 April to 1879 May	1879 June to 1880 July	Mean
	″				″		″	
Mean	+0.314	+0.173	+0.029	—0.362	—0.018	+0.195	+0.195	
I	—0.236	+0.459	—0.208	—0.190	—0.181	+0.263	+0.009	—0.01
II	— .257	+ .129	+ .053	— .130	— .100	— .172	— .124	— .09
III	— .194	— .228	+ .069	— .151	+ .095	+ .053	+ .119	— .03
IV	— .313	+ .312	+ .051	— .319	— .363	— .183	+ .099	— .10
V	— .519	— .024	+ .004	— .452	— .352	— .521	+ .181	— .21
VI	— .443	+ .115	+ .065	— .501	— .179	+ .129	+ .127	— .10
VII	— .325	+ .101	+ .056	— .019	— .136	— .010	— .089	— .06
VIII	— .097	— .022	— .127	— .023	+ .015	+ .406	+ .028	+ .03
IX	+ .266	+ .094	+ .165	+ .092	+ .053	+ .113	— .222	+ .12
X	+ .345	+ .344	+ .198	+ .133	+ .037	— .070	— .062	+ .18
XI	+ .855	— .343	+ .186	+ .427	+ .122	— .194	+ .057	+ .20
XII	+ .524	— .124	+ .083	+ .416	+ .118	— .164	— .094	+ .15
XIII	+0.397	— .510	— .654	+ .187	+ .355	— .177	+ .039	— .05
XIV		—0.333	—0.540	+ .215	+0.220	+0.034	—0.073	—0.08
XV				+0.341				

The figures in this table will probably be considered by all as justifying the rough inferences which I have drawn; and I hope that the data given in this article may serve to facilitate a more elaborate study of the curious phenomenon under consideration.

It may be well to call attention once more to the signification of the algebraic signs used throughout this article. For convenience, and to diminish the danger of confusion, the southern declinations and latitude have been treated as positive; so that the values, here entitled C.—O., correspond to what would be O.—C. in the general formulas, and the terms maximum and minimum must be interchanged when compared with the corresponding extremes in the northern hemisphere. Consequently the quantities in the last column of the table just given represent the numerical increase and decrease of the southern latitude, and may be considered as values of $-kc$, if φ be counted from the equator northward.

An unfortunately large number of typographical errors exist in the tables of southern circumpolars, given in the Introduction to vol. V of the Cordoba Results. This Introduction was printed during the weeks immediately preceding my return from Cordoba, at a time when my health was seriously impaired, — a circumstance which may perhaps be accepted as a valid apology.

Many of these errors are indicated in the Corrigenda at the end of the same volume, p. 556; and one, not typo-

graphical, is corrected in vol. X, p. 263. The following additional ones have been detected during the course of these computations. After they, too, shall have been corrected, the tables will, I trust, prove worthy of full reliance.

Page xxxvi	Cordoba right-ascension 1877	*for*	$0^h\ 19^m\ 50^s.56$	*put*	$0^h\ 19^m\ 15^s.56$
xxxvii	Epoch for Melbourne position 1871,	"	1881.0	"	1871.0
"	Epoch for Cordoba positions 1872,	"	1872.9	"	1872.0
"	Determination for 1875.5,	"	Melbourne	"	Cordoba
xxxix	Epoch for Cordoba position 1873,	"	1872.0	"	1873.0
xliii	Mean place 1870.0 for Cordoba 1878,	"	30″.05	"	29″.78
"	Mean place 1870.0 for Cordoba 1880,	"	30″.42	"	30″.32
	and change the values C. — O. accordingly				
lvii	Name of star,	*for*	*ζ Mensae*	*put*	*ε Mensae*
lxxxviii	Last line but two,	the sign of *B* should be +			
cxvi, cxvii	Name of star	*for*	*κ Octantis*	*put*	*χ Octantis.*
cxxxix	Melbourne Declination	"	82 43 49.12	*put*	82 42 49.12

Other unannounced errors in the Cordoba volumes are:

Vol V, p. 127, col. 2,	*for*	*δ Muscae*	*put*	*δ Muscae*, culm. inf.
X, p. 157, col. 3, line 1	"	*λ Orionis*	"	*λ Octantis*
p. 157, col. 3, line 2	"	Set.	"	Oct.
XII, p. 212, col. 1,	"	*ο Octantis*	"	*ο Octantis*, culm. inf.
p. 220, col. 3,	"	*ι Octantis*	"	*ι Octantis*
XIII, p. 395, col. 3	"	*B Octantis*	"	*B Octantis*, culm. inf.

THE RELATIVE MOTION OF 61 *CYGNI*.

By A. HALL.

Accurate observations of the angle of position and distance of this remarkable star begin about 1825, and have been continued to the present time. The relative motion is so nearly rectilinear that doubt has frequently been expressed as to the physical connection of these stars, and it has been assumed that they will gradually separate and hereafter follow widely different paths through space.

My observations of this star with the Washington 26-inch refractor extend from 1879 to 1891. In the following discussion these measurements of distance have been reduced to a value of a revolution of the micrometer-screw = 9″.936; which is 0″.012 smaller than the one adopted in the reductions, and a value which better suits my measurements. In order to test the question of relative motion, I have combined these observations with those given in volume IX of the *Pulkowa Observations*, p. 229. The observed angles have been reduced to the epoch 1860.0 by means of the formula for the yearly change,

$$\frac{dp}{dt} = n \sin \alpha \sec \delta$$

Denoting by p and s the angle of position and the distance, the following table gives the quantities used in my computation. The first columns give the date, the observer, the angles of position reduced to the above epoch, and the distances. The next columns give the rectangular coordinates,

$$x = s \sin p, \qquad y = s \cos p.$$

The motion was then assumed to be rectilinear, and after adjustment of the coefficients the equations for this motion were found to be

$$\begin{aligned} s \sin p &= +16''.990 + (0''.0311) \cdot [t-1860.0] \qquad \text{(A)} \\ s \cos p &= -\ 5''.597 - (0''.1857) \cdot [t-1860.0] \end{aligned}$$

The columns Δx and Δy give the residuals found by comparing formulas (A) with the observations. It will be seen that the residuals in Δx are opposed to the theory of a rectilinear motion of these stars. Terms depending on the square of the time were then introduced, and after an adjustment of the coefficients by least squares the following formulas were found:

$$\begin{aligned} s \sin p = +17''.203 + (0''.384) \cdot [t-1860.0] \qquad \text{(B)} \\ -(0''.000570) \cdot [t-1860.0]^2 \\ s \cos p = -\ 5''.667 - (0''.1859) \cdot [t-1860.0] \\ +(0''.000176) \cdot [t-1860.0]^2 \end{aligned}$$

These formulas give the residuals $\Delta x'$, $\Delta y'$. The probable errors of a single value are

$$\text{for } \Delta x', \quad r = \pm 0''.059; \qquad \text{for } \Delta y', \quad r = \pm 0''.050$$

It will be seen that the result is in favor of the physical connection of these stars. However, empirical formulas deduced in this way cannot be applied beyond the time embraced in the discussion, with much safety, and they give but little idea of the period of revolution, except that it is long.

If this system is binary a certain point on the line joining the stars should divide the distance in a constant ratio. I have made a rough attempt to determine this point, and find its distance from the star of reference to be less than one-third the distance between the stars; or the mass of the brighter star is 3.4 times that of the companion.

Date	Observer	p	s	Observed x	Observed y	C − O Δx	C − O Δy	C − O Δx	C − O Δy
		°	"	"	"	"	"	"	"
1830.68	W. Struve	90.41	15.473	+15.473	− 0.111	+0.508	−0.041	+0.111	+0.045
1832.09	"	91.34	15.737	15.733	0.368	+0.297	−0.046	−0.046	+0.027
1835.65	"	93.71	15.967	15.934	1.033	+0.218	−0.012	−0.004	0.003
1837.06	"	94.71	16.009	15.954	1.323	+0.247	−0.014	+0.068	+0.013
1843.53	O. Struve	98.95	16.670	16.467	2.593	−0.061	+0.054	−0.054	+0.036
1847.46	"	100.84	17.023	16.719	3.202	−0.160	−0.066	−0.088	−0.106
1850.30	"	102.35	17.180	16.782	3.675	−0.126	−0.121	−0.005	−0.172
1851.81	"	103.63	17.310	16.852	4.086	−0.111	+0.010	−0.001	−0.046
1852.67	"	104.16	17.460	16.907	4.360	−0.169	+0.121	−0.016	+0.065
1854.25	"	105.22	17.575	16.959	4.614	−0.167	+0.085	+0.004	+0.022
1857.20	"	106.54	18.020	17.274	5.130	−0.380	+0.053	−0.183	−0.015
1860.80	"	108.77	18.227	17.258	5.865	−0.240	+0.119	−0.024	+0.049
1868.51	"	112.54	18.810	17.373	7.210	−0.089	+0.027	+0.116	−0.032
1874.74	"	116.17	19.125	17.434	8.567	+0.063	+0.233	+0.211	+0.198
1879.71	A. Hall	117.78	19.955	17.655	9.301	+0.013	+0.014	+0.084	+0.058
1881.17	"	118.17	20.110	17.728	9.491	−0.010	−0.034	+0.033	−0.030
1883.27	"	118.89	20.420	17.879	9.866	−0.080	−0.052	−0.091	−0.032
1885.19	"	120.12	20.533	17.761	10.304	+0.096	+0.029	+0.047	+0.066
1887.17	"	120.63	20.709	17.820	10.551	+0.105	−0.091	+0.005	−0.037
1889.20	"	121.34	20.994	17.931	10.919	+0.063	−0.100	−0.093	−0.026
1891.16	"	122.08	21.129	+17.903	−11.222	+0.159	−0.161	−0.056	−0.067

As a test of equations (B) a comparison has been made with Bradley's position of the companion, and with the early observations of Bessel and W. Struve, which were made with small instruments. The results are as follows: (C−O).

Bradley,	1755.00	$\Delta x = -1''.27$;	$\Delta y = +0''.89$
Bessel,	1812.30	$\Delta x = -2.35$;	$\Delta y = +0.37$
Struve,	1821.62	$\Delta x = -0.05$;	$\Delta y = +0.31$

These residuals might be reduced by small changes in the coefficients, but the early observations are not as accurate as the modern ones, and as Bradley's difference of declination depends on a single observation, no change has been made.

1892 *March* 3.

ON TWO NEW VARIABLES IN *CEPHEUS.*

BY PAUL S. YENDELL.

1855.0.

$\alpha = 22^h\ 28^m\ 35^s$ $\delta = 55°\ 52'.6$

My observations, from 1890 Sept. 21 to the present time, appear to indicate that the star DM. 55° 2769 is a variable of long period.

The star was used as a comparison-star for another suspected variable, and was itself early suspected by me of variability. A series of 198 observations seems to have established the fact, two maxima and a minimum having been observed.

The extreme range of variation observed is a full magnitude, from 5M.8 to 6M.8; but the star is apparently subject, especially near its maxima, to sudden and considerable fluctuations in light, often amounting to several steps from one night to the next; the mean range is about 0.8, from 5M.9 to 6M.7; the period appears to be about a year.

The comparison-stars used, with the light-scale formed from the observations, are as follows:

1855.0

	α	δ	m	m Y	Light
	h m s	° '			
λ = λ *Cephei*	21 6 37.7	58 11.8	5.6	5.6	21.8
o = DM. 56° 2821	22 32 16.5	56 2.7	6.0	6.0	16.0
e = 55° 2820	22 43 18.4	55 7.9	5.9	6.33	11.7
a = 55° 2779	22 30 11.6	55 19.2	6.8	6.8	5.5

The star's color is to my eye sensibly white.

The original observations are too numerous to give here in detail, but the monthly means, indicating maxima on 1891 Jan. 18 and 1892 Jan. 11, and a minimum about 1891 July 7, are as follows; the dates given are the mean date for each month, and in the column of weights is given the number of observations forming each mean.

	L	W		L	W
1890 Sept. 25.7	7.9	7	1891 June 11.6	7.0	[illegible]
Oct. 15.7	8.6	14	July 16.2	7.4	14
Nov. 15.0	11.4	19	Aug. 15.4	8.3	[illegible]
Dec. 11.5	13.6	14	Sept. 13.6	8.8	[illegible]
1891 Jan. 15.9	16.0	16	Oct. 14.7	[illegible]	[illegible]
Feb. 12.7	14.0	14	Nov. 16.7	[illegible]	14
Mar. 12.3	13.4	8	Dec. 15.0	[illegible]	14
Apr. 18.5	11.9	2	1892 Jan. 13.8	17.3	14
May 17.2	8.0	[illegible]	Feb. 14.0	15.4	

It is very desirable that this star's variation should be confirmed by other observers.

1855.0.

$\alpha = 23^h\ 19^m\ 11^s$ $\delta = +82°\ 23'.0$

This star, which is (8594) of Chandler's "List of Stars Probably Variable," published in the Supplement [illegible]

Edition of his *Catalogue of Variable Stars*. I have had under constant observation since July 1889. The result of my observations confirms the star's variability, and indicates a light-range of about 0M.7, from 6M.2 to 6M.9, in an average period of about 318 days, three maxima and three minima having been observed, as follows:

Maxima	M	Minima	M
1890 Jan. 10	6.2	1889 Sept. 3	6.7
1891 Feb. 21	6.2	1890 July 5	6.9
1892 Jan. 25	6.2	1891 June 3	6.9

The comparison-stars used are

1855.

		α	δ	m	m Y	Light
		h m s	° ′			
a =	DM. 81°517	22 51 15	84 35.8	6.5	6.42	7.3
b =	81° 13	0 29 1	81 11.6	6.5	6.58	5.5
c =	83° 20	0 18 25	83 49.4	7.0	6.95	1.3
f =	82° 718	23 55 23	82 10.0	7.0	7.06	0.0

In both the above tables of comparison-stars the magnitudes in the column *m* are the DM. magnitudes; those in the column *m Y* are the estimates formed by myself from the light-scales.

Dorchester, Mass., 1892 *March* 3.

TABLE FOR WEIGHTING ZENITH-TELESCOPE OBSERVATIONS.

By HAROLD JACOBY.

The following little table may perhaps be found useful in selecting stars for latitude-determinations by TALCOTT's method. We occasionally meet with the statement that, in order to eliminate from the final latitude the effect of any error in the adopted value of the micrometer-screw, we must select the pairs so that the mean of all the declinations shall be equal to the latitude. But this is only strictly true, if all the pairs enter into the result with equal weight. If we let e be the probable error of one observation, e_δ, $e_{\delta'}$ be the probable errors of the two declinations of any pair, n be the number of times the pair has been observed, and put:

$$E^2 = e_\delta^2 + e_{\delta'}^2,$$

then the weight of the resulting latitude from that pair is:

$$p = \frac{1}{E^2 + \frac{4e^2}{n}} \tag{1}$$

and the condition to be fulfilled, in order that the adopted screw value may be without effect upon the final latitude is:

$$\Sigma(pM) = 0 \tag{2}$$

when M is the difference of zenith-distances as measured by the micrometer, and always taken in the sense, northern star *minus* southern star. In the table I have set down the values of p corresponding to various values of e and E^2. The column headed I contains the weight corresponding to a single observation of the pair, the succeeding columns give the *additional* weight acquired, when further observations are added to the first. Thus for $E^2 = 0''.06$, $e = 0''.2$, the weight from a pair observed once would be 4.6; for second observation made, the additional weight is 2.6, and the total weight 7.2.

I have found it convenient to note upon the observing list, opposite each pair, the values given in the columns I, II, III, etc., of the table. It is thus possible to tell by a glance at the observing list exactly how much a given observation will add to the positive or negative side of $\Sigma(pM)$; and whenever it is necessary to decide between two conflicting pairs, that one can be selected which comes nearest to satisfying the condition (2). It is generally possible to keep the condition approximately satisfied continuously throughout a whole series of latitude-observations. The table will also be found practically useful in selecting pairs so as to secure any desired final weight, with a minimum amount of time spent in observing.

	$e = 0''.1$						$e = 0''.2$						$e = 0''.3$						$e = 0''.4$				
E^2	I	II	III	IV	V	E^2	I	II	III	IV	V	E^2	I	II	III	IV	V	E^2	I	II	III	IV	V
″						″						″						″					
0.02	16.7	8.3	5.0	3.3	2.4	0.02	5.6	4.4	3.6	3.0	2.6	0.02	2.6	2.4	2.1	1.9	1.8	0.02	1.5	1.4	1.3	1.3	1.2
.04	12.5	4.2	2.1	1.3	0.8	.04	5.0	3.3	2.4	1.8	1.4	.04	2.5	2.0	1.7	1.4	1.2	.04	1.5	1.3	1.1	1.1	1.0
.06	10.0	2.5	1.1	0.6	0.4	.06	4.6	2.6	1.7	1.2	0.9	.06	2.1	1.8	1.4	1.1	0.9	.06	1.4	1.2	1.0	0.9	0.8
.08	8.3	1.7	0.7	0.4	0.3	.08	4.2	2.1	1.2	0.8	0.6	.08	2.3	1.6	1.2	0.9	0.7	.08	1.4	1.1	0.9	0.8	0.6
.10	7.1	1.2	0.5	0.3	0.2	.10	3.8	1.7	1.0	0.6	0.4	.10	2.2	1.4	1.0	0.7	0.5	.10	1.3	1.0	0.8	0.7	0.5
.12	6.3	0.9	0.4	0.2	0.1	.12	3.6	1.4	0.8	0.5	0.3	.12	2.1	1.2	0.8	0.6	0.4	.12	1.3	1.0	0.7	0.6	9.5
.14	5.6	0.7	0.3	0.1	0.1	.14	3.3	1.2	0.6	0.4	0.3	.14	2.0	1.1	0.7	0.5	0.4	.14	1.3	0.9	0.7	0.5	0.4
0.16	5.0	0.6	0.2	0.1	0.1	0.16	3.1	1.0	0.5	0.3	0.2	0.16	1.9	1.0	0.6	0.4	0.2	0.16	1.2	0.8	0.6	0.4	0.3

Columbia College, New York, 1892 *February* 22.

THE POSITION OF THE NEW STAR IN AURIGA.

Observations of T. REED, Princeton, N. J.

(Communicated by Prof. Young.)

Mr. Reed has determined the position of the new star as follows, by six meridian-circle observations of the object in connection with β *Tauri*, the place of which was taken from the Berlin *Jahrbuch*. The observations are reduced to 1892.0, all corrections having been duly applied.

On February 6 the star was estimated a quarter of a magnitude brighter than χ *Aurigae*, on the 13th, as quarter of a magnitude fainter.

	1892.0	1892.0
	h m s	° ′ ″
1892 Feb. 9	α 5 25 3.23	δ +30 21 48.7
10	3.30	50.5
11	3.27	48.3
12	3.36	48.7
15	3.29	49.9
16	3.34	49.3
Mean	5 25 3.30	+30 21 49.2

OBSERVATIONS OF THE SPECTRUM OF *NOVA AURIGAE.*

By C. A. YOUNG, Princeton, N. J.

I have succeeded in determining the positions of 12 bright lines in the spectrum of the new star. The wave-lengths deduced are the following:

4340 (H_γ); 449; 4861 (F); 4922; 5015; 5165; 5260; 5301; 559; 590 (D?); 632; 6563 (C). In addition to these a faint line was glimpsed below C on Feb. 6, and another above G, — in all probability h ($H\delta$). The lines are not *persiennes*, but true lines, though rather diffuse, as if formed under pressure; C and F especially. The lines at 4922 and 5015 cannot be identical with the two principal lines of the ordinary nebular spectrum, as the nebula of *Orion* was used along with the spectrum of the moon, to determine the constants of the micrometer-scale. The error of the four-figure places cannot well exceed one or two in the last place; the three-figure places are of course more uncertain. It may be worth noting that the two lines at 559 and 632 may possibly be found to coincide with the two principal auroral lines at 5571, and 632. My own determination of the position of the red line on the evening of Feb. 13, made it 633½, by a single-prism spectroscope and scale, the constants being determined from the moon.

SOME OBSERVATIONS OF THE NEW STAR IN *AURIGA.*

By PAUL S. YENDELL.

From February 9 to this time, I have obtained twelve observations of this star.

With the exception of the first observation, the star has been observed with the field-glass, the comparison-stars with a provisional estimate of their magnitudes, being as follows:

	1855.0 α	1855.0 δ	Mag	Light
	h m s	° ′ ″		
a = *F*. 26 *Aurigae*	5 29 11.9	+30 23.9	5.8	17.8
b = DM. 30° 898	17 51.4	30 1.2	6.0	14.3
c = 29° 909	20 27.9	+29 3.9	6.4	10.0

The dates of observation and estimated magnitudes by the above scale are

		M	
1892 Feb.	9.323	6.0±	[illegible]
	15.323	6.2	
	16.333	6.2	
	" later	6.0	
	17.302	6.2	
	18.309	5.9	
	22.306	6.1	
Mar.	4.302	6.25	Bright moon.
	5.312	6.25	" "
	6.319	6.4	" "
	7.313	6.6	" " [illegible]
	9.388	6.8	" " [illegible]

The star, when first observed, showed little or no color to my eye; later examination with the telescope, however, shows a slight yellow tinge.

Dorchester, Mass., 1892 *March* 9.

Mr. Sawyer has sent, by letter, the following observations in addition to those given in no. 257. He states that they are relatively uncertain, especially that of March 5, on account of the proximity of the moon; and that the star has a slight tinge of yellow.

The comparison-stars used were, as on p. 126, *F* 26 and DM. 30° 869.

	M		M
March 4.27	6.1	March 6.40	6.2
5.42	5.95	7.31	6.3

DISCOVERY OF A COMET,

BY LEWIS SWIFT.

On the morning of March 7, at 5^h 10^m, while seeking for comets with my 4½-inch telescope, I ran upon what at first sight, from its general appearance, I was sure was a comet. After some unusual delay, the 16-inch glass was turned on the object, but advancing daylight prevented the getting of its place with desired accuracy. Fortunately, I had at 3 o'clock set my automatic R.A. circle to the R.A. of the meridian, and the following is the position read from it: 18^h 59^m, the Decl. circle recording —31° 20′. It is possible that it is BROOKS's comet of 1886, though its great southern declination and its brightness both argue against the supposition. For a telescopic comet, it exceeds in size and brilliancy any I have ever seen.

Clouds have prevented any observation since discovery.

Warner Observatory, Rochester, N.Y., 1892 March 9.

COMET *b* 1892 (*SWIFT*).

An observation by BARNARD has been telegraphed from the Lick Observatory; and Prof. FRISBY of the Washington Observatory sends one which he has made there.

	Greenw. M.T.	α	δ
		h m s	° ′ ″
BARNARD	1892 Mar. 8.0399	19 3 25.3	—30 32 53
FRISBY	11.9487	19 22 14.8	—27 18 48

From these observations, and a third by himself Mar. 12, Rev. G. M. SEARLE of the Catholic University at Washington has computed the following elements and ephemeris:

$$T = 1892 \text{ April } 26.99 \text{ Greenw. M.T.}$$

$$\left.\begin{aligned} \omega &= 81^\circ\ 33' \\ \Omega &= 237\ \ 34 \\ i &= 64\ \ 29 \end{aligned}\right\} \text{Eq. } 1892.0$$

$$q = 0.5891$$

EPHEMERIS FOR GREENWICH MEAN TIME.

Date	α	δ	Brightness
	h m s	° ′	
1892 Mar. 16.5	19 45 44	—22 36	1.82
20.5	20 7 48	—17 11	
24.5	20 31 16	—11 58	
28.5	20 56 20	— 5 30	4.08

The brightness on March 6 was taken as unity.

NEW ASTRONOMICAL WORK.

Astronomical Papers, prepared for the use of the American Ephemeris and Nautical Almanac, under the direction of SIMON NEWCOMB, *Professor U.S.N., Superintendent.* Vols. II, III. Washington, 1891.

The issue of this important series of papers, in volumes, took place during the past autumn, and should have been announced here some months ago; but accident prevented.

No notice is called for, other than an enumeration of the important papers which the volumes contain, and whose titles tell their own story.

VOL. II.

1. Formulas and Tables for expressing corrections to the geocentric place of a Planet in terms of symbolic corrections to the Elements of the Orbits of the Earth and Planet, by SIMON NEWCOMB, assisted by JOHN MEIER.
2. Investigations of Corrections to the Greenwich Planetary Observations from 1762 to 1830, by TRUMAN HENRY SAFFORD.
3. Measures of the Velocity of Light made under the direction of the Secretary of the Navy during the years 1880–1882, by SIMON NEWCOMB.
4. Supplementary Measures of the Velocities of white and colored Light in air, water, and carbon disulphide, made with the aid of the Bache fund of the National Academy of Sciences, by ALBERT A. MICHELSON.
5. Discussion of Observations of the Transits of *Venus* in 1761 and 1769, by SIMON NEWCOMB.
6. Discussion of the North Polar Distances observed with the Greenwich and Washington Transit Circles, with a determination of the constant of Nutation, by SIMON NEWCOMB.

VOL. III.

1. Development of the Pertubative Function and its Derivatives, in sines and cosines of multiples of the eccentric anomalies, and in powers of the eccentricities and inclinations, by SIMON NEWCOMB.
2. Determination of the Inequalities of the Moon's Motion, which are produced by the Figure of the Earth: a Supplement to DELAUNAY's Lunar Theory, by GEORGE W. HILL.
3. On the Motion of *Hyperion*; a new case in Celestial Mechanics, by SIMON NEWCOMB.
4. On certain Lunar Inequalities, due to the Action of *Jupiter*, and discovered by Mr. E. NEISON, by GEORGE W. HILL.
5. Periodic Perturbations of the Longitudes and Radii Vectores of the four Inner Planets, of the first order as to the masses, computed under direction of SIMON NEWCOMB.

These several memoirs had previously been issued separately. Vol. IV published in 1890 consists of HILL's New Theory of *Jupiter* and *Saturn*. [See *A.J.* X, 72.]

CONTENTS.

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VOL. XI. BOSTON, 1892 MARCH 31. NOS. 19 AND 20.

THE ORBIT OF *HYPERION*.

PRESENTED AS A THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY AT THE JOHNS HOPKINS UNIVERSITY.

BY W. S. EICHELBERGER, ASSISTANT IN ASTRONOMY IN WESLEYAN UNIVERSITY.

§1. INTRODUCTION.

On the 19th of September, 1848, an eighth satellite of *Saturn* was discovered by Mr. W. C. BOND of Cambridge, Mass., and on the same evening, by Mr. LASSELL of Liverpool.

Owing to its extreme faintness, during the first quarter of a century after its discovery, but few observations of it were made. About fifteen years ago, however, Professor ASAPH HALL, by the aid of the 26-inch equatorial at the U. S. Naval Observatory, began a series of observations which extends to the present time.

Attention was first called to the peculiarity of its motion by Professor HALL's papers in the *Astronomische Nachrichten*, and one in the *Monthly Notices*, R.A.S., for May, 1884. In this latter paper he points out the fact that the peri-saturnium of *Hyperion* has a yearly retrograde motion of 20°±, and adds, that "on account of its mean distance and the eccentricity of its orbit, *Hyperion* can approach very near to *Titan*; and, since three times the period of one is nearly equal to four times the period of the other, there is probably a large perturbation of the motion of *Hyperion* by *Titan*."

Professor NEWCOMB shows[1] that this remarkable retrograde motion of the peri-saturnium is due to the mutual attraction of these two satellites, and obtains the perturbations of the elements as functions of the mean angular separation of their peri-saturnia. The value that he deduces for the mass of *Titan*, after correcting an error pointed out by HILL,[2] is $m = \frac{1}{4267}$.

Mr. F. TISSERAND has written an article[3] in which he considers the perturbative effect of two bodies revolving in circular orbits about their primary, and shows, that if the mean motions are in a ratio that approaches very near to commensurability, and the mass of one is very small compared with the other, the orbit of the smaller will become quite eccentric, and its peri-centron will retrograde. Since *Titan*, from its greater brilliancy, is considered much larger than *Hyperion*, these satellites afford him an actual example; and, assuming the eccentricity of the latter's orbit to be 0.1, and that it is entirely due to the perturbative effect of *Titan*, he deduces a value of the mass of *Titan*, $m = \frac{1}{[illegible]}$.

The subject has been still further treated by STONE,[4] and HILL,[5] by different methods, both deriving nearly the same mass for *Titan*.

In the fall of 1889, by the advice of Professor NEWCOMB, I resolved to devote myself to this problem. I take this opportunity to express my obligations to Professor NEWCOMB for his many suggestions and encouragements.

As a preliminary step to the determination of the perturbative effect of *Titan*, it was decided to obtain more accurately the elements of *Hyperion*; and this problem has so grown that the present paper will be confined to its consideration.

§2. OBSERVATIONS OF *HYPERION*.

To deduce the elements of *Hyperion* recourse was had to the Washington Observations. About twenty were taken from each of nine oppositions, during the years 1875–[illegible], usually covering a period of two months.

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[1] On the Motion of *Hyperion*. A New Case in Celestial Mechanics. Astronomical Papers of the *American Ephemeris*, 1884.

[2] *Astronomical Journal*, No. 176.

[3] TISSERAND. *Sur un Cas Remarquable du Problème des Perturbations*. *Comptes-Rendus*, 1886, 2e Semestre, p. 446.

[4] *Annals of Mathematics*, Vol. III, p. [illegible] and Vol. IV, p. [illegible]

$n = $ [illegible]

[5] *Astronomical Journal*, No. 176 [illegible]

Greenw. M.T.	p	s
	°	″
1873		
Aug. 26.6672	269.81	193.91
29.6026	283.30	197.91
31.5751	299.81	121.18
Sept. 6.5863	87.59	216.00
9.6188	99.11	227.62
11.5958	110.21	152.90
19.5003	281.99	201.03
20.5578	287.91	175.72
29.5059	91.10	235.16
Oct. 2.5196	108.11	166.91
3.1799	118.11	117.79
17.1712	75.59	112.67
19.4863	88.20	209.86
20.1529	92.10	223.96
21.1917	96.21	226.71
22.4728	100.01	210.91
24.4251	112.10	134.95
28.4313	261.00	131.55
29.4305	268.50	174.73
1877		
Oct. 2.5856	273.40	225.98
12.5138	89.02	151.81
13.5271	91.31	191.92
14.1962	92.99	215.19
14.5334	92.98	215.58
15.5012	94.27	219.58
Nov. 6.1758	95.35	204.22
27.4330	94.83	202.29
29.4266	97.95	139.28
30.4211	102.75	83.31
Dec. 6.4332	273.92	220.89
7.4331	275.08	222.91
8.3993	276.12	209.48
9.4138	277.65	180.86
14.4613	84.06	82.26
15.4408	88.89	130.59
1879		
Oct. 10.5970	90.70	220.39
12.6390	83.02	118.86
13.5885	73.80	93.78
16.6508	285.48	123.88
19.5160	274.69	217.95
1879		
Oct. 20.5641	272.52	260.34
23.5810	265.65	190.60
24.5885	260.88	131.51
31.5322	91.22	220.58
Nov. 3.5766	77.80	102.76
10.5177	273.05	252.86
11.1879	271.41	252.16
12.5185	269.25	233.75
13.4597	267.29	199.76
14.1632	263.29	119.75
21.1727	92.28	215.80
29.1308	277.76	186.16
30.1308	275.49	222.01
1880		
Oct. 10.6214	352.63	62.11
11.6219	307.93	96.28
12.6031	291.53	147.29
14.5831	278.17	230.88
15.5678	274.35	253.02
16.5793	270.70	257.58
23.6158	107.35	111.69
24.5637	99.80	189.76
25.5799	94.20	222.38
31.5522	12.59	59.76
Nov. 1.5651	315.60	80.76
2.5139	294.53	129.86
7.5383	268.60	218.06
9.5640	259.03	176.16
11.5609	218.25	61.84
12.5512	141.67	60.66
16.5114	90.90	228.28
17.1985	87.39	224.23
20.5209	63.77	106.86
21.5055	30.77	62.34
1883		
Dec. 1.5633	82.58	271.91
2.6172	75.87	255.77
3.5798	68.47	226.98
5.6169	10.85	110.49
6.5625	13.20	111.21
9.5607	289.25	181.53
10.5577	277.93	213.85
1883		
Dec. 17.5212	132.25	133.51
27.5298	19.07	112.06
1884		
Jan. 2.1879	262.20	219.61
21.1801	282.00	194.12
22.1502	272.58	213.63
23.4272	264.28	214.82
25.5131	241.11	156.87
26.4523	221.35	118.21
29.5331	118.58	155.99
Dec. 4.6198	355.60	105.00
7.5971	279.98	200.87
8.5828	269.79	223.28
9.5794	260.39	225.19
15.5781	123.98	165.21
19.5685	87.98	280.62
26.5105	327.06	114.96
1885		
Jan. 2.5323	221.65	139.49
8.5287	95.62	261.69
9.5437	89.27	271.89
10.5272	83.28	275.12
12.4723	70.01	231.56
13.5043	59.55	193.06
17.6180	301.92	115.07
21.5273	255.15	209.34
22.4991	244.00	180.80
29.4581	97.10	246.99
1887		
Jan. 18.5683	232.00	173.63
22.5185	128.52	146.99
24.5309	102.79	220.86
25.5538	91.50	244.85
26.5482	87.82	256.50
27.5395	84.45	249.26
30.5067	46.22	133.32
Feb. 11.5254	156.25	115.54
12.5070	130.92	112.29
13.5179	114.52	179.61
16 5511	88.75	250.47
22.5034	325.15	98.76
24.4956	278.65	188.31
1887		
Feb. 27.1766	254.72	228.89
28.1567	246.12	208.13
Mar. 1.4636	235.22	176.40
2.5082	218.02	140.28
10.5077	83.25	240.12
11.1618	76.42	221.35
12.4511	67.25	188.06
1888		
Jan. 18.5755	170.75	98.00
19.5802	135.60	115.03
21.5613	103.69	193.66
30.5428	285.11	162.01
Feb. 1.5681	267.75	246.84
2.5490	262.27	260.33
8.5394	182.82	100.20
13.5422	90.65	234.91
15.5036	77.69	219.68
16.6007	67.28	175.97
18.5003	16.62	80.55
28.5319	220.15	135.28
Mar. 6.5035	86.75	233.80
7.5015	80.02	222.61
8.5058	71.80	191.65
9.4967	59.32	145.41
14.1696	272.32	215.33
15.4806	265.98	241.83
17.5111	254.05	239.04
18.5092	247.45	216.12
1890		
Feb. 21.6185	256.57	220.35
26.5831	105.15	107.33
Mar. 2.5673	81.30	207.27
8.5630	276.58	175.14
9.5508	271.20	223.55
11.4928	265.46	272.58
15.5071	253.06	188.04
23.5415	82.20	208.02
Apr. 11.5428	93.15	172.63
12.4854	88.15	199.10
19.5203	281.75	137.53
21.5246	269.95	227.41
22.5509	267.00	252.84

In the first column, the time has been corrected for aberration.

In the second and third columns, the correction for differential refraction has been applied, and in addition the third column has been corrected for the change in s during the interval between the observations of position-angle and of distance.

§3. Comparison of Observations with Assumed Elements.

The following formulas were used in computing the tabular places:

$$\xi = r\frac{\rho_0}{\rho}\Delta\sin f\sin(F+u)$$

$$\eta = r\frac{\rho_0}{\rho}\Delta\sin g\sin(G+u)$$

$$\zeta = r\frac{\rho_0}{\rho}\Delta\sin h\sin(H+u)$$

$$x = s\sin p = \frac{\xi}{1+\zeta}$$

$$y = s\cos p = \frac{\eta}{1+\zeta}$$

f, g, h, F, G and H being given by the following:

$$\sin f\sin F = -\sin(\alpha-N)$$

$$\sin f\cos F = \cos(\alpha-N)\cos J$$

$$\cos f = -\cos(\alpha-N)\sin J$$

$$\sin g\sin G = -\sin\delta\cos(\alpha-N)$$

$$\sin g\cos G = l\cos(\delta+L)$$

$$\cos g = q\cos(\delta-Q)$$

$$\sin h\sin H = \cos\delta\cos(\alpha-N)$$

$$\sin h\cos H = l\sin(\delta+L)$$

$$\cos h = q\sin(\delta-Q)$$

$$l \sin L = \cos J \sin(\alpha - N)$$
$$l \cos L = \sin J$$
$$q \sin Q = \sin J \sin(\alpha - N)$$
$$q \cos Q = \cos J$$

The following notation has been employed.

E = Mean longitude of Satellite.
P = Longitude of Peri-saturnium of Satellite's Orbit.
M = Mean Anomaly.
N = Longitude of Node on the Equator.
n = " " " Ecliptic.
J = Inclination of Orbit to Equator.
i = " " Ecliptic.
e = Eccentricity of Orbit.
μ = Mean Motion in Longitude.
Δ = Mean Distance of Satellite from Planet, as seen at distance ρ_0 of Planet.
ρ_0 = Assumed Mean Distance of Planet from Sun.
ρ = Geocentric Distance of Planet.
α = Right-Ascension of Planet.
δ = Declination of Planet.
v = True Anomaly of Satellite.
ε = Eccentric Anomaly of Satellite.
u = Longitude of Satellite in Orbit, starting from Node on the Equator.
s = Observed Distance of Satellite.
p = Observed Position-Angle.
w = Distance along Orbit from Node on Equator to Node on Ecliptic.

The values of f, g, h, F, G, H, were computed for every five days during the periods of observation; the values for each observation being found by interpolation.

The value of E for each opposition is the mean of the values obtained from two or three observations about midway of the corresponding series, by means of the following formulas:

$$\tan u = \frac{s \cos p \dfrac{\sin F}{\sin g} - s \sin p \dfrac{\sin G}{\sin f}}{s \sin p \dfrac{\cos G}{\sin f} - s \cos p \dfrac{\cos F}{\sin g}}$$

$$v = u - w + n - P$$
$$M = v - \text{equation of center}$$
$$E = M + P$$

The other elements were obtained mostly from NEWCOMB's paper referred to above.

The rectangular coordinates were computed for comparison with those obtained from the observed distance and position-angle.

The assumed elements, referred to the mean equinox of the date are as follows:

Epoch	1875 Oct. 0.0	1877 Nov 0.0	1879 Nov. 0.0	1880 Nov. 0.0	1884 Jan. 0.0
	° ′	° ′	° ′	° ′	° ′
E	63 13.1	339 39.2	95 51.7	181 2.5	298 50.0
P	174 1.6	130 13.2	86 21.7	61 2.5	357 31.5
ΔP	—19 12.9	—21 12.5	—22 24.1	—22 10.3	—19 21.9
N	123 52.3	123 57.1	124 1.8	124 1.1	124 11.8
J	6 35.2	6 35.0	6 34.7	6 34.6	6 31.3
e	0.10	0.10	0.08	0.08	0.10

Epoch	1885 Jan. 0.0	1887 Feb. 15.0	1888 Feb. 15.0	1890 Mar. 14.0
	° ′	° ′	° ′	° ′
E	0 30.0	174 2.0	234 16.0	93 43.0
P	338 44.2	302 12.0	286 16.0	253 13.0
ΔP	—18 15.8	—16 15.0	—15 15.0	—15 53.0
N	124 14.1	124 19.0	124 19.0	124 19.0
J	6 31.2	5 50.0	5 50.0	5 50.0
e	0.10	0.12	0.12	0.12

$$\Delta = 214''.00$$
$$\mu = 16^\circ.91988$$
$$\rho_0 = 9.53887$$

ρ, α, and δ were taken from the *British Nautical Almanac*.

Comparison of Observations.

Date	x(obs.)	x(comp	O—C	Resid.	y(obs.)	y comp	O—C	Resid.	Date	x obs.	x comp	O—C	Resid.	y obs.	y comp	O—C	Resid.
	″	″	″	″						″							
1875 Aug 26	—193.94	—188.67	— 5.27	—0.31	— 0.64	— 1.01	+ 0.37	—0.15	1877 Oct 13	+191.87	+169.26	+22.61	—0.10	— 4.39	— 4.10	— 0.29	—0.55
29	192.63	195.65	+ 3.02	—0.52	+ 45.54	+ 46.53	— 0.99	+0.60	14	215.20	201.47	+13.73	+0.75	11.24	10.52	0.72	+0.1[illegible]
31	—105.15	—110.76	+ 5.61	+0.08	60.24	60.59	— 0.35	0.00	14	215.23	202.38	+12.85	+1.32	11.20	10.76	0.44	0.17
Sep 6	+215.80	+211.49	+ 4.31	—0.63	+ 9.08	+ 8.02	+ 1.06	+0.34	15	218.97	216.12	+ 2.85	+1.59	16.35	16.26	0.09	— 0.19
9	224.75	224.88	— 0.13	—0.09	— 36.04	— 37.44	+ 1.40	+0.15	Nov 6	203.33	206.30	— 2.97	+0.69	19.04	19.18	+ 0.14	— 0.04
11	+143.49	+145.25	— 1.76	—0.75	— 52.82	— 54.20	+ 1.38	0.36	27	201.57	201.47	+ 0.10	+0.66	17.0[illegible]	17.23	+ 0.20	+0.3[illegible]
19	—199.58	—199.95	+ 0.37	—0.51	+ 42.38	+ 43.16	— 0.78	0.65	29	137.94	148.38	—10.44	—0.61	19.26	21.27	+ 2.01	—0.71
20	—167.20	—166.45	— 0.75	+1.25	+ 54.04	+ 54.68	— 0.64	—0.50	30	+ 81.28	+ 94.38	13.10	— 1.44	— 18.39	— 19.64	+ 1.25	— 1.00
29	+234.86	+233.45	+ 1.41	—0.07	— 16.84	18.46	+ 1.62	+ 1.26	Dec 6	220.38	217.90	2.48	+0.52	+ 15.50	+ 16.78	1.28	+0.0[illegible]
Oct 2	158.40	157.19	+ 1.21	+1.01	52.72	52.73	+ 0.01	+ 1.58	7	221.94	223.46	+ 1.52	+0.70	19.7[illegible]	20.77	[illegible]	—0.24
3	103.90	102.08	+ 1.82	+0.65	— 55.50	— 55.59	+ 0.09	+0.68	8	208.29	213.57	+ 5.28	+0.67	22.3[illegible]	23.54	1.2[illegible]	+[illegible]
17	138.18	141.72	— 3.54	+0.52	+ 35.50	+ 32.22	+ 3.28	0.10	9	—179.25	—188.60	+ 9.35	+0.49	24.08	24.79	0.71	0.2[illegible]
19	209.76	211.27	— 1.51	+0.70	+ 6.59	+ 1.98	+ 4.61	0.52	11	+ 81.82	+ 63.57	+18.25	0.74	8.5[illegible]	8.02	+ 0.49	— [illegible]
20	223.81	224.76	— 0.95	+1.40	— 8.21	— 13.19	+ 4.98	0.83	15	+130.57	+113.65	+16.92	— 1.40	+ 2.53	+ 1.87	+ 0.66	0.28
21	225.38	222.22	+ 3.16	—0.72	24.52	28.41	+ 3.89	0.01	1879 Oct 10	+220.38	+218.12	+ 2.26	0.13	2.70	— 1.67	1.03	+1.11
22	207.73	202.71	+ 5.02	—0.79	36.67	40.57	+ 3.90	0.61	12	147.76	141.78	+ 5.98	0.16	+ 18.09	+ 20.4[illegible]	2.3[illegible]	+0.[illegible]
24	+125.03	+116.83	+ 8.20	0.81	50.77	53.77	+ 3.00	1.80	13	+ 90.06	+ 83.46	+ 6.60	+0.08	26.16	28.24	2.08	—0.2[illegible]
28	—132.89	—137.46	+ 4.57	+1.05	21.05	18.59	— 2.46	—1.16	16	— 119.39	125.02	+ 5.63	+0.05	33.06	36.60	3.54	+0.[illegible]
29	—171.67	—177.72	+ 3.05	+0.10	— 4.57	— 0.61	— 3.96	0.48	19	247.12	248.23	+ 1.11	+0.23	20.27	21.8[illegible]	1.5[illegible]	[illegible]
1877 Oct 2	—225.58	—210.47	—15.11	+0.10	+ 13.10	+ 11.52	+ 1.88	1.85	20	260.09	259.57	0.52	+0.45	+ 11.45	+ 13.15	— 1.70	+0.19
12	+151.84	+122.57	+29.27	—1.23	+ 2.60	+ 2.73	— 0.13	—0.86	23	—190.05	—184.57	— 5.48	+1.18	11.46	15.02	+ 0.56	+0.5[illegible]

Date	x obs.	x comp.	O−C	Resid.	y obs.	y comp.	O−C	Resid.
1879	″	″		″	″			″
Oct 24	−132.81	−128.01	− 4.80	−0.42	− 21.32	− 22.87	+ 1.55	+0.12
31	+220.53	+218.70	+ 1.83	−0.52	− 4.70	− 5.53	+ 0.83	−0.25
Nov 3	+100.44	+ 95.61	+ 4.83	+1.11	+ 21.72	+ 23.83	− 2.11	+0.05
10	−252.50	−253.71	+ 1.21	−0.86	13.45	15.42	− 1.97	+0.12
11	252.38	251.33	− 1.05	−0.05	+ 6.20	+ 7.22	− 1.02	−0.12
12	233.73	230.56	− 3.17	+0.73	− 3.06	− 1.92	− 1.14	+0.85
13	199.54	196.07	− 3.47	−0.03	9.44	10.11	+ 0.67	−0.19
14	−148.72	−141.94	− 3.78	−0.60	17.50	18.02	+ 0.52	+0.75
21	+215.63	+214.81	+ 0.82	+0.03	− 8.59	− 8.67	+ 0.08	+0.89
29	−184.75	−188.23	+ 3.48	−0.42	+ 25.18	+ 28.90	− 3.72	+0.73
30	−220.99	−223.55	+ 2.56	−0.69	+ 21.24	21.04	− 2.80	+0.16
1880								
Oct 10	− 7.97	− 5.82	− 2.15	−0.84	+ 61.60	62.82	− 1.22	−0.78
11	75.94	73.61	− 2.33	−0.29	59.18	62.11	− 2.93	+0.36
12	137.01	134.67	− 2.34	+0.14	54.05	57.15	− 3.10	+0.26
14	228.53	227.11	− 1.42	−0.05	32.81	36.18	− 3.37	+0.69
15	252.29	251.12	− 1.17	0.00	19.19	21.74	− 2.55	+0.24
16	−257.56	−257.39	− 0.17	−0.66	+ 3.15	+ 5.41	− 2.26	+0.48
23	+135.24	+129.26	+ 5.98	−1.80	− 42.25	− 45.85	+ 3.60	−0.23
24	187.00	182.45	+ 4.55	−0.76	32.30	34.65	+ 2.35	+1.14
25	221.78	219.16	+ 2.62	+0.34	− 16.29	− 18.91	+ 2.62	+0.59
31	+ 13.03	+ 11.43	+ 1.60	+0.24	+ 58.32	+ 59.34	− 1.02	−0.96
Nov 1	− 56.50	− 57.34	+ 0.84	+0.57	57.70	59.98	− 2.28	0.00
2	118.14	119.80	+ 1.66	−0.22	+ 53.91	+ 56.41	− 2.50	+0.07
7	247.99	246.91	− 1.08	−0.56	− 6.06	− 6.07	+ 0.01	−0.29
9	173.23	170.37	− 2.86	+0.40	33.58	34.78	+ 1.20	−0.08
11	− 38.28	− 35.80	− 2.48	+0.84	48.56	50.44	+ 1.88	+0.15
12	+ 37.62	+ 39.68	− 2.06	+1.22	47.58	50.94	+ 3.36	−0.70
16	228.25	227.43	+ 0.82	−1.50	− 3.59	− 6.06	+ 2.47	−0.79
17	224.00	222.02	+ 1.98	−1.15	+ 10.21	+ 10.03	+ 0.18	+0.73
20	95.86	91.53	+ 4.33	+0.37	47.23	49.36	− 2.13	+0.66
21	+ 31.89	+ 27.60	+ 4.29	+0.96	+ 53.56	+ 55.27	− 1.71	−0.22
1883								
Dec 1	+269.64	+271.59	− 1.95	+0.96	+ 35.12	+ 35.55	− 0.43	+0.54
2	248.03	250.89	− 2.86	−0.38	62.44	63.32	− 0.88	−0.08
3	211.14	215.86	− 4.72	−0.48	83.30	84.67	− 1.37	−0.58
5	91.89	101.17	− 9.28	+0.37	106.27	111.19	− 4.92	+1.00
6	+ 25.39	+ 35.74	−10.35	+0.14	108.27	112.75	− 4.48	−0.37
9	−171.38	−163.37	− 8.01	−0.75	59.85	67.22	− 7.37	−0.21
10	−211.80	−206.11	− 5.69	+0.40	+ 29.50	+ 37.37	− 7.87	−0.10
17	+ 98.83	+ 82.80	+16.03	−0.45	− 89.77	− 93.18	+ 3.41	+0.25
27	+ 36.61	+ 49.94	−13.33	+0.06	+105.91	+110.84	− 4.93	+0.35
1884								
Jan 2	−217.58	−221.73	+ 4.15	+0.40	− 29.80	− 20.81	− 8.99	+0.50
21	189.88	179.02	−10.86	−0.09	+ 40.36	+ 50.48	−10.12	−0.26
22	213.41	208.78	− 4.63	−0.31	+ 9.62	+ 21.00	−11.38	+0.55
23	213.75	216.93	+ 3.18	−0.56	− 21.41	− 10.72	−10.69	+0.43
25	137.35	154.58	+17.23	+1.17	75.79	70.34	− 5.45	+0.11
26	− 78.10	−100.28	+22.18	+0.25	88.74	86.13	− 2.61	+0.30
29	+136.98	+116.81	+20.17	−0.45	− 74.62	− 80.52	+ 5.90	−0.63
Dec 4	− 8.06	− 16.41	+ 8.35	+0.20	+104.69	+106.98	− 2.29	+1.12
7	197.83	201.79	+ 3.96	−0.42	+ 34.81	+ 32.61	+ 2.20	−0.15
8	223.28	225.46	+ 2.18	−0.05	− 0.82	− 3.58	+ 2.76	−0.34
9	−223.03	−222.83	+ 0.80	+0.58	37.59	39.73	+ 2.14	+0.38
15	+137.02	+135.29	+ 1.73	−0.48	− 92.35	− 92.11	− 0.24	−0.16
19	+280.45	+277.18	+ 3.27	+0.26	+ 9.89	+ 15.21	− 5.32	+0.58
26	− 62.51	− 70.30	+ 7.79	+0.53	+ 96.48	+ 96.46	+ 0.02	−0.38
1885								
Jan 2	− 92.70	− 93.06	+ 0.36	+0.55	−104.23	−105.82	+ 1.59	+0.57
8	+260.43	+257.96	+ 2.47	−0.44	− 25.63	− 21.80	− 3.83	+0.17
9	274.87	272.49	+ 2.38	+0.80	+ 3.50	+ 8.57	− 5.07	+0.48
10	273.52	268.94	+ 4.58	+0.11	32.23	37.41	− 5.18	−0.12
12	+220.42	+211.61	+ 8.81	−0.84	+ 80.18	+ 85.46	− 5.28	+0.03
1885	″	″	″	″	″	″	″	″
Jan 13	+166.43	+156.97	+ 9.46	+0.22	+ 97.84	+102.24	− 4.40	−0.08
17	−123.13	−130.27	+ 7.14	−0.04	+ 76.70	+ 74.55	+ 2.15	−0.89
21	−202.35	202.92	+ 0.57	+0.13	− 53.65	− 56.20	+ 2.55	+0.39
22	−162.50	−163.52	+ 1.02	−0.62	79.26	82.31	+ 3.05	−0.33
29	+244.93	+243.79	+ 1.14	+0.27	− 31.81	− 29.62	− 2.19	−1.36
1887								
Jan 18	−136.82	−130.31	− 6.51	+0.78	−106.90	−107.21	+ 0.31	+0.48
22	+115.00	+120.94	− 5.94	−0.22	91.54	90.73	− 0.81	−0.68
24	215.38	218.85	− 3.47	−0.42	48.89	45.72	− 3.17	+0.93
25	244.09	247.17	− 3.08	+0.85	− 19.21	− 17.26	− 1.95	−0.45
26	256.31	256.52	− 0.21	−0.18	+ 9.76	+ 11.67	− 1.91	−0.50
27	246.49	245.63	+ 0.86	+0.65	37.06	39.58	− 2.52	+0.30
30	96.26	91.39	+ 4.87	+0.32	+ 92.24	+ 91.61	+ 0.63	−1.37
Feb 11	46.53	47.14	− 0.61	+0.43	−105.75	−106.64	+ 0.89	−0.79
12	107.52	107.79	− 0.27	+0.04	93.20	93.78	+ 0.58	−0.37
13	163.41	163.26	+ 0.15	−0.41	− 74.54	− 74.67	+ 0.13	+0.18
16	+250.43	+251.03	− 0.60	+0.22	+ 5.46	+ 5.70	− 0.24	+0.73
22	− 56.43	− 53.40	− 3.03	−0.44	81.05	80.31	+ 0.74	−2.18
24	186.31	183.88	− 2.43	−0.07	+ 28.34	+ 32.66	− 4.32	+1.69
27	220.74	222.48	+ 1.74	+0.61	− 60.31	− 58.25	− 2.06	−0.92
28	190.20	194.27	+ 4.07	−0.22	84.21	81.34	− 2.87	+0.45
Mar 1	144.79	150.12	+ 5.33	−0.25	100.55	98.63	− 1.92	+0.24
2	− 86.32	− 92.97	+ 6.65	−0.80	−110.41	−108.91	− 1.50	+0.68
10	+238.41	+239.70	− 1.29	−0.32	+ 28.22	+ 25.26	+ 2.96	+0.24
11	215.08	219.62	− 4.54	+0.68	51.95	49.76	+ 2.19	+0.64
12	+173.29	+179.26	− 5.97	−0.42	+ 72.67	+ 70.65	+ 2.02	+0.05
1888								
Jan 18	+ 15.75	+ 3.35	+12.40	−0.17	− 96.73	− 94.01	− 2.72	+1.83
19	80.48	69.06	+11.42	−0.66	82.19	83.57	+ 1.38	−1.19
21	+188.16	+180.61	+ 7.55	−1.06	− 45.83	− 47.25	+ 1.42	+0.25
30	−156.41	−148.22	− 8.19	−2.52	+ 42.23	+ 47.13	− 4.90	+0.41
Feb 1	246.66	242.23	− 4.43	−0.27	− 9.69	− 4.00	− 5.69	−0.52
2	257.96	256.49	− 1.47	+0.18	35.01	29.68	− 5.33	−0.90
8	− 4.93	− 9.58	+ 4.65	+0.70	100.08	97.68	− 2.40	+0.52
13	+234.89	+234.27	+ 0.62	−0.05	− 2.66	− 2.52	− 0.14	−0.52
15	214.63	214.97	− 0.34	+0.73	+ 46.84	+ 47.55	− 0.71	+0.39
16	162.31	164.21	− 1.90	+1.94	67.96	68.08	− 0.12	−0.01
18	+ 23.00	+ 25.90	− 2.90	+0.94	+ 77.05	+ 78.89	− 1.84	+1.38
28	− 87.11	− 84.58	− 2.53	+0.14	−103.26	−100.70	− 2.56	+0.04
Mar 6	+233.41	+232.01	+ 1.40	−0.49	+ 13.25	+ 17.26	− 4.01	+0.56
7	219.14	215.91	+ 3.23	−0.80	38.56	42.19	− 3.63	+0.72
8	181.88	176.35	+ 5.53	+0.12	59.80	62.46	− 2.66	+0.62
9	+124.89	+116.73	+ 8.16	−1.25	74.09	75.18	− 1.09	+0.02
14	−215.30	−216.68	+ 1.38	0.00	+ 8.72	+ 10.23	− 1.51	+1.35
15	241.31	240.52	− 0.79	+1.01	− 16.96	− 16.37	− 0.59	+0.08
17	229.77	227.32	− 2.45	+0.38	65.67	63.59	− 2.08	+1.00
18	−199.47	−195.51	− 3.96	+0.54	− 82.82	− 80.54	− 2.28	+0.94
1890								
Feb 21	−214.32	−207.95	− 6.37	+0.37	− 51.18	− 49.21	− 1.97	+1.03
26	+103.60	+110.99	− 7.39	−1.63	− 28.05	− 27.48	− 0.57	−1.00
Mar 2	+204.89	+202.38	+ 2.51	−1.18	+ 31.35	+ 31.85	− 0.50	+0.21
8	−173.99	−175.66	+ 1.67	−0.98	20.07	19.25	+ 0.82	−1.46
9	223.50	223.11	− 0.39	+0.17	+ 4.68	+ 6.31	− 1.63	+0.74
11	271.73	270.53	− 1.20	−1.13	− 21.58	− 19.78	− 1.80	+0.62
15	−179.88	−170.71	− 9.17	+0.05	− 54.79	− 53.77	− 1.02	+0.54
23	+206.09	+204.40	+ 1.69	0.00	+ 28.23	+ 29.44	− 1.21	+0.15
Apr 11	171.58	181.59	−10.01	+1.57	− 9.49	− 6.01	− 3.48	+0.58
12	+199.00	+203.98	− 4.98	+1.13	+ 6.43	+ 9.73	− 3.30	+0.74
19	−131.65	−140.13	+ 5.48	+0.93	+ 28.01	26.50	+ 1.51	−0.80
21	227.41	229.32	+ 1.91	+0.65	− 0.20	+ 0.27	− 0.47	+1.10
22	−252.49	−251.62	− 0.87	+0.66	− 13.23	− 13.63	+ 0.40	+0.12

§4. EQUATIONS OF CONDITION.

In the equations of condition, we have employed seven variables, the correction to the mean longitude being separated into two parts, thus:

$$dE = dE_0 + t\,d\mu$$

The form of the equations arising from the residuals in x, is

$$a(dE_0 + t\,d\mu) + b\cdot e\,dP + c\cdot de + d\cdot dA + e\cdot \sin J\,dN + f\cdot dJ = n$$

where

$$a = \frac{f'}{\cos\varphi}\left\{\cos(F+u) + e\cos(F'+P)\right\}$$

$$b = -\frac{f'}{\cos\varphi}\left\{\cos(F+u)\left(\cos\varepsilon\cos\varphi + \frac{e}{1+\cos\varphi}\right) + \cos(F'+P)\right\}$$

$$c = \frac{f'}{\cos\varphi}\left\{\cos(F+u)\sin\varepsilon - \sin(F'+P)\cos\varphi\right\}$$

$$d = \frac{\xi}{\Delta}$$

$$e = -f'tg\tfrac{1}{2}i \cdot r\cos(F+u)\cos w - \frac{\rho_0}{\rho}\, r\cos f\cos u$$

$$f = f'tg\tfrac{1}{2}i \cdot r\cos(F+u)\sin w + \frac{\rho_0}{\rho}\, r\cos f\sin u$$

in which $f' = \frac{\rho_0}{\rho}\sin f$

and $F' = F - u + w$

The corresponding equation in y is obtained by replacing e, f, F, and ξ by g, G, and η respectively.

In order to facilitate the solution of the normal equations, certain transformations were made in the equations of condition for the different oppositions, as follows:

1875
$x = 2\,dE$
$y = 45\,d\mu$
$z = 4\,e\,dP$
$u = 3\,de$
$v = 3\,dI$
$w = 2\sin J\,dN$
$t = 2\,dJ$

1877
$x = 2\,dE$
$y = 60\,d\mu$
$z = 1\,e\,dP$
$u = 4\,de$
$v = 3\,dI$
$w = 2\sin J\,dN$
$t = 3\,dJ$

1879
$x = 2\,dE$
$y = 30\,d\mu$
$z = 2\,e\,dP$
$u = 4\,de$
$v = 3\,dI$
$w = 3\sin J\,dN$
$t = 2\,dJ$

1880
$x = 2\,dE$
$y = 30\,d\mu$
$z = 4\,e\,dP$
$u = 3\,de$
$v = 2\,dI$
$w = 2\sin J\,dN$
$t = 2\,dJ$

1883–4
$x = 2\,dE$
$y = 15\,d\mu$
$z = 3\,e\,dP$
$u = 4\,de$
$v = 2\,dI$
$w = 2\sin J\,dN$
$t = 2\,dJ$

1884–5
$x = 3\,dE$
$y = 45\,d\mu$
$z = 3\,e\,dP$
$u = 4\,de$
$v = 3\,dI$
$w = 2\sin J\,dN$
$t = 2\,dJ$

1887
$x = 3\,dE$
$y = 15\,d\mu$
$z = 5\,e\,dP$
$u = 3\,de$
$v = 3\,dI$
$w = 2\sin J\,dN$
$t = 2\,dJ$

1888
$x = 3\,dE$
$y = 45\,d\mu$
$z = 5\,e\,dP$
$u = 3\,de$
$v = 3\,dI$
$w = 2\sin J\,dN$
$t = 3\,dJ$

1890
$x = 3\,dE$
$y = 45\,d\mu$
$z = 2\,e\,dP$
$u = 6\,de$
$v = 4\,dI$
$w = 2\sin J\,dN$
$t = 4\,dJ$

The transformed equation will then be

$$a'_0x + a'_1y + b'z + c'u + d'v + e'w + f't = n$$

where the coefficients have the values given in the following table.

The first line at each date contains the coefficients of the equation arising from the residual in x; the second, those of the equation arising from the residual in y.

Equations of Condition.

Gr. M.T.	a_0'	a_1'	b'	c'	d'	e'	f'	n
1875								″
Aug 26.6672	−0.279	+0.425	+0.335	+0.114	−0.294	+0.041	−0.090	− 5.27
	+0.147	−0.225	−0.119	0.094	0.002	−0.060	+0.496	+ 0.37
29.6026	0.222	0.310	+0.202	0.367	−0.305	−0.089	0.010	+ 3.02
	0.091	0.127	−0.065	0.102	+0.073	+0.383	0.339	0.99
31.5754	0.430	0.562	+0.315	0.478	−0.173	−0.145	0.079	+ 5.61
	0.019	0.025	−0.056	0.055	+0.094	+0.536	0.068	0.35
Sep 6.5863	+0.233	−0.243	+0.340	0.100	0.330	−0.061	+0.114	+ 4.31
	−0.125	+0.130	−0.114	0.095	0.012	+0.134	0.578	+ 1.06
9.6188	0.178	0.162	+0.215	0.276	+0.350	+0.057	+0.025	0.13
	0.097	0.088	−0.066	0.121	−0.058	−0.280	−0.454	+ 1.40
11.5958	0.444	0.363	+0.308	0.436	+0.226	+0.117	0.046	− 4.76
	−0.030	+0.025	−0.049	0.077	−0.084	−0.454	0.190	+ 1.38
19.5003	+0.175	−0.082	+0.192	0.331	−0.312	0.076	−0.003	+ 0.37
	0.104	0.049	−0.071	0.112	+0.067	+0.331	+0.374	− 0.78
20.5578	0.314	0.132	+0.228	0.426	−0.259	−0.113	0.036	0.75
	0.067	−0.028	−0.057	0.089	+0.085	+0.445	0.250	− 0.64
29.5059	+0.013	0.000	+0.235	0.154	+0.364	+0.003	+0.069	+ 1.41
	−0.121	+0.003	−0.091	0.125	−0.029	−0.093	−0.544	1.62
Oct 2.5196	0.400	−0.045	+0.279	0.112	+0.245	+0.108	0.034	1.21
	0.044	0.005	−0.048	0.087	−0.082	−0.422	0.238	0.01
3.4799	0.498	−0.077	+0.356	0.436	+0.159	+0.126	0.065	1.82
	−0.003	0.000	−0.053	0.060	−0.086	−0.464	−0.087	+ 0.69
17.4721	+0.366	+0.284	+0.408	0.153	+0.221	−0.112	+0.128	− 3.54
	−0.107	−0.083	−0.112	0.059	0.050	+0.331	0.465	+ 3.28
19.4863	+0.171	+0.148	+0.296	0.092	0.329	0.047	+0.100	− 1.51
	−0.125	−0.108	0.107	0.106	0.003	+0.085	0.551	+ 1.61
20.4529	+0.052	+0.048	+0.242	0.126	+0.350	0.010	+0.076	0.95
	−0.122	−0.111	−0.093	0.122	−0.024	0.045	0.538	+ 4.98
21.4917	0.087	0.083	+0.208	0.203	+0.346	+0.031	+0.044	3.16
	0.109	0.104	−0.074	0.126	0.044	0.180	0.485	3.89
22.4728	0.222	0.222	+0.212	0.294	+0.316	+0.066	+0.011	5.02
	0.087	0.086	−0.057	0.117	−0.063	0.294	0.397	3.90
24.4254	0.455	0.494	+0.324	0.115	+0.182	+0.117	0.054	8.20
	0.016	0.018	−0.048	0.068	−0.084	0.438	0.135	3.00
28.4313	−0.392	−0.495	+0.392	0.119	0.214	+0.076	−0.099	+ 1.57
	+0.136	+0.172	−0.119	0.071	0.029	0.209	+0.411	2.46
29.4305	−0.215	−0.320	+0.304	0.100	0.277	+0.036	0.082	+ 3.05
	+0.145	+0.490	−0.115	+0.099	−0.001	0.062	+0.460	3.96
1877								
Oct 2.5856	−0.285	+0.270	+0.229	−0.272	−0.228	+ [illegible]	+ [illegible]	− 5.11
	+0.051	−0.048	0.010	+0.070	+0.018	+ [illegible]	[illegible]	[illegible]
12.5438	+0.420	−0.258	+0.135	−0.370	0.191	0.070	+ [illegible]	+ 29.17
	−0.055	+0.034	0.002	+0.053	0.004	+0.165	[illegible]	− [illegible]
13.5271	+0.325	−0.190	+0.204	−0.335	+0.261	0.064	+ [illegible]	+ [illegible]
	−0.054	+0.032	−0.006	+0.055	0.006	+0.012	[illegible]	[illegible]
14.4962	+0.196	−0.108	+0.191	0.268	+0.314	0.053	[illegible]	+ [illegible]
	−0.019	+0.027	−0.002	+0.052	−0.016	[illegible]	[illegible]	[illegible]
14.5334	+0.191	−0.105	+0.191	−0.265	+0.317	0.053	[illegible]	+ 12.87
	−0.019	+0.027	−0.002	+0.052	−0.017	0.117	[illegible]	[illegible]
15.5042	+0.031	−0.016	+0.203	−0.183	+0.337	0.057	[illegible]	+ 2.85
	−0.039	+0.020	0.002	+0.044	0.025	[illegible]	0.284	[illegible]
Nov 6.4758	0.098	−0.021	0.238	0.128	+0.321	0.022	0.024	− [illegible]
	0.030	0.006	0.004	+0.039	[illegible]	[illegible]	[illegible]	+ [illegible]
27.4330	0.042	0.038	0.205	−0.147	+ [illegible]	0.027	[illegible]	[illegible]
	0.033	0.030	0.005	+0.040	0.027	[illegible]	[illegible]	+ [illegible]
29.4266	−0.365	−0.358	+0.370	0.112	+0.271	+0.012	[illegible]	− [illegible]
	+0.026	+0.025	−0.008	+0.026	[illegible]	0.118	[illegible]	[illegible]
30.4241	−0.480	−0.487	+0.432	0.171	+0.117	+ [illegible]	[illegible]	[illegible]
	+0.022	+0.022	−0.018	+0.028	[illegible]	[illegible]	+ [illegible]	[illegible]
Dec 6.4332	−0.114	−0.138	+0.188	0.182	[illegible]	+ [illegible]	[illegible]	− [illegible]
	+0.041	+0.049	−0.001	+0.044	+ [illegible]	[illegible]	[illegible]	[illegible]
7.4331	0.018	0.022	+0.216	0.125	[illegible]	[illegible]	[illegible]	[illegible]
	0.029	0.037	0.001	+0.037	+ [illegible]	[illegible]	[illegible]	[illegible]
8.3993	0.136	0.174	+0.266	0.096	[illegible]	[illegible]	[illegible]	[illegible]
	0.017	0.022	0.001	+0.070	+ [illegible]	+0.172	[illegible]	[illegible]
9.4138	0.246	0.323	+0.325	0.099	0.294	[illegible]	[illegible]	[illegible]
	0.004	0.005	−0.006	+0.026	+ [illegible]	+ [illegible]	[illegible]	[illegible]
14.4613	+0.481	+0.639	+ [illegible]	0.370	[illegible]	[illegible]	+ [illegible]	+ [illegible]
	−0.048	0.070	0.018	+0.055	[illegible]	+ [illegible]	[illegible]	[illegible]
15.4108	+0.377	+0.571	+ [illegible]	0.349	[illegible]	[illegible]	+ [illegible]	[illegible]
1878	−0.050	0.076	0.012	+0.050	+ [illegible]	+ [illegible]	[illegible]	[illegible]
Oct 10.5970	−0.122	+0.167	−0.006	0.203	+0.240	[illegible]	− [illegible]	+ [illegible]
	+0.091	0.124	0.155	+ [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.6390	0.439	+0.537	+0.099	[illegible]	+0.221	+ [illegible]	[illegible]	+ [illegible]
	+0.075	0.091	0.109	+ [illegible]	[illegible]	[illegible]	+ [illegible]	[illegible]
13.5885	−0.520	+0.601	0.003	[illegible]	[illegible]	+ [illegible]	[illegible]	[illegible]
	+0.057	0.066	0.085	+0.046	[illegible]	[illegible]	+ [illegible]	[illegible]

Gr. M.T.	a_0	a_1'	b'	c'	d'	e'	f'	n
[illegible]								″
Oct 16.6508	—0.482	+0.461	—0.423	0.465	0.195	+0.062	0.065	+ 5.63
	0.012	0.012	0.083	+0.014	+0.057	0.051	+0.579	— 3.54
19.5460	0.160	0.123	0.293	—0.028	—0.387	0.035	0.015	+ 1.11
	0.062	0.047	0.136	+0.018	+0.034	0.316	+0.375	— 1.56
20.5644	0.047	0.012	0.156	0.271	0.401	0.020	0.006	0.52
	—0.072	+0.050	0.143	+0.029	+0.020	+0.372	0.243	1.70
23.5840	+0.391	—0.193	+0.017	0.438	0.288	—0.029	+0.060	— 5.48
	0.068	+0.034	—0.104	+0.053	0.023	+0.372	—0.208	+ 0.56
24.5885	+0.491	—0.210	0.034	—0.506	0.200	—0.042	+0.070	— 4.80
	—0.056	+0.024	0.082	+0.051	—0.036	+0.314	—0.341	+ 1.55
31.5322	—0.072	—0.003	0.048	—0.286	+0.341	0.006	+0.007	1.83
	+0.083	+0.003	—0.143	+0.034	—0.009	0.338	—0.118	0.83
Nov 3.5766	0.499	—0.119	+0.026	0.517	+0.149	+0.045	—0.070	+ 4.83
	+0.059	+0.014	—0.082	+0.047	+0.037	—0.272	+0.373	— 2.14
10.5175	0.061	—0.043	0.187	—0.265	—0.395	+0.024	0.002	+ 1.21
	—0.063	—0.014	—0.129	+0.025	+0.024	0.349	0.285	— 1.97
11.4879	+0.085	+0.065	+0.063	—0.283	—0.392	0.009	0.022	1.05
	0.069	—0.053	—0.129	+0.035	+0.014	+0.385	0.150	1.02
12.5185	+0.226	+0.189	+0.030	—0.336	0.359	0.008	+0.040	3.17
	—0.071	—0.059	—0.119	+0.045	0.003	+0.396	—0.005	1.14
13.4597	+0.345	+0.310	+0.053	—0.404	0.306	—0.023	+0.055	— 3.47
	—0.067	—0.060	—0.102	+0.050	0.016	+0.380	—0.145	+ 0.67
14.4632	+0.451	+0.435	0.001	—0.476	0.226	—0.037	+0.066	— 3.78
	—0.058	—0.056	0.084	+0.050	—0.028	+0.334	—0.283	+ 0.52
21.4727	—0.019	—0.027	0.099	—0.268	+0.335	0.012	0.013	0.82
	+0.075	+0.108	0.132	+0.030	—0.014	—0.317	0.169	+ 0.08
29.4308	—0.338	—0.664	0.421	—0.344	—0.293	+0.051	—0.040	+ 3.48
	0.030	0.059	0.089	+0.012	+0.045	0.167	+0.510	— 3.72
30.4308	0.223	0.452	0.347	—0.287	—0.348	0.041	—0.023	+ 2.56
	—0.045	—0.091	—0.106	+0.015	+0.037	+0.252	+0.432	— 2.80
1880								
Oct 10.6211	—0.540	+0.733	—0.414	—0.512	—0.014	+0.104	—0.095	— 2.15
	+0.013	—0.018	0.040	+0.030	+0.147	—0.078	+0.584	1.22
11.6249	—0.517	+0.668	0.450	—0.418	—0.172	+0.103	—0.092	2.33
	0.023	0.029	0.054	+0.038	+0.145	0.082	+0.585	2.93
12.6034	0.460	0.564	0.448	—0.317	—0.314	0.096	—0.083	2.34
	0.055	0.068	0.071	+0.056	+0.133	0.232	+0.546	3.10
14.5834	0.258	0.282	0.347	—0.186	—0.530	0.063	—0.048	1.42
	0.107	0.117	0.092	+0.101	+0.084	0.481	+0.361	3.37
15.5678	0.124	0.128	0.278	—0.190	—0.586	0.039	—0.025	1.17
	—0.123	+0.126	0.091	+0.114	+0.051	0.560	+0.228	2.55
16.5793	+0.027	—0.026	0.218	—0.248	—0.601	0.012	0.001	0.17
	—0.130	+0.125	0.081	+0.115	+0.013	+0.600	0.076	— 2.26
23.6158	+0.505	—0.249	0.458	—0.284	+0.302	—0.079	+0.066	+ 5.98
	0.075	0.037	0.076	+0.063	—0.107	0.229	—0.452	3.60
24.5637	0.372	0.160	0.387	—0.207	+0.427	0.061	+0.047	4.55
	0.109	0.047	0.092	+0.090	—0.081	0.373	—0.352	2.35
25.5799	0.192	0.070	0.287	—0.199	+0.512	0.035	+0.021	2.62
	+0.133	0.048	0.097	+0.113	—0.044	—0.486	—0.206	2.62
31.5522	—0.538	—0.020	0.397	—0.532	+0.027	+0.101	—0.093	+ 1.60
	+0.024	+0.001	0.034	+0.030	+0.138	—0.134	+0.574	— 1.02
Nov 1.5651	—0.524	—0.055	0.442	—0.444	—0.134	+0.104	—0.091	+ 0.84
	0.011	0.001	0.047	+0.065	+0.140	0.027	+0.590	— 2.28
2.5439	0.475	0.081	0.449	—0.343	—0.280	0.098	—0.083	+ 1.66
	—0.043	—0.007	0.062	+0.062	+0.132	+0.180	+0.564	— 2.50
7.5383	+0.146	+0.074	0.191	—0.318	—0.577	—0.007	+0.020	— 1.08
	—0.124	—0.062	0.064	+0.148	0.014	+0.596	—0.028	+ 0.01
9.5640	+0.435	+0.278	0.242	—0.517	0.398	—0.058	+0.062	— 2.86
	—0.094	—0.060	0.031	+0.136	0.081	+0.471	—0.322	+ 1.20
11.5609	+0.596	+0.459	0.415	—0.524	0.084	—0.088	+0.081	— 2.48
	0.026	0.020	0.026	+0.085	—0.118	+0.184	—0.495	+ 1.88
12.5542	+0.593	+0.496	0.468	—0.431	+0.093	—0.090	+0.079	— 2.06
	—0.004	—0.004	0.033	+0.073	—0.119	+0.011	—0.514	+ 3.36
16.5414	+0.045	+0.050	0.216	—0.244	+0.531	—0.014	0.001	0.82
	0.133	0.146	0.085	+0.128	—0.014	—0.526	0.092	2.47
17.4985	0.129	0.151	0.169	—0.344	+0.518	+0.015	—0.026	1.98
	+0.131	+0.153	0.070	+0.142	0.023	—0.546	+0.070	0.18
20.5209	—0.490	—0.670	0.301	—0.570	0.214	+0.086	—0.083	+ 4.33
	+0.064	+0.088	0.027	+0.104	0.115	—0.320	+0.482	— 2.13
21.5055	—0.526	—0.754	0.374	—0.538	0.064	+0.097	—0.089	+ 4.29
1883	+0.032	+0.046	—0.029	+0.082	+0.129	—0.182	+0.551	— 1.71
Dec 1.5633	—0.081	+0.106	—0.234	+0.250	+0.634	+0.049	—0.045	— 1.95
	+0.220	—0.288	+0.287	0.105	0.083	—0.487	+0.429	0.43
2.6172	—0.226	+0.285	—0.329	0.264	0.586	+0.069	—0.079	2.86
	+0.193	—0.243	+0.277	0.069	0.148	—0.372	+0.525	0.88
3.5798	—0.344	+0.419	—0.395	0.311	0.504	+0.083	—0.106	4.72
	+0.155	—0.189	+0.249	+0.046	+0.198	—0.243	+0.580	— 1.37

Gr. M.T.	a_0'	a_1'	b'	c'	d'	e'	f'	n
1883								″
Dec 5.6169	—0.522	+0.589	—0.404	+0.463	+0.236	+0.096	—0.138	— 9.28
	+0.014	—0.050	+0.169	0.044	0.260	0.068	+0.576	4.92
6.5625	—0.560	+0.608	—0.337	0.522	0.083	0.092	—0.140	10.35
	0.018	0.020	+0.112	0.066	+0.263	0.212	+0.517	4.48
9.5607	0.410	0.391	—0.048	0.166	—0.381	0.042	—0.083	8.01
	0.212	0.202	+0.195	0.157	+0.157	0.520	+0.124	7.37
10.5577	0.259	0.235	—0.041	0.373	—0.481	0.015	—0.046	5.69
	—0.255	+0.232	+0.248	0.157	+0.087	+0.536	—0.046	— 7.87
17.5212	+0.579	—0.347	—0.266	0.533	+0.194	—0.069	+0.115	+16.03
	+0.091	—0.055	+0.121	0.122	—0.218	—0.411	—0.320	+ 3.41
27.5298	—0.546	+0.081	—0.356	0.501	+0.117	+0.094	—0.137	—13.33
1884	—0.002	0.000	+0.144	0.059	+0.259	+0.163	+0.532	— 4.93
Jan 2.4879	+0.086	+0.010	—0.211	0.249	—0.518	—0.033	+0.025	+ 4.15
	—0.260	—0.029	+0.296	0.104	0.049	+0.428	—0.303	— 8.99
21.4804	0.322	0.308	—0.035	0.400	—0.418	0.029	—0.062	10.86
	0.223	0.213	+0.210	0.151	+0.118	0.507	+0.056	10.12
22.4502	0.162	0.162	—0.065	0.313	—0.188	0.003	—0.026	4.63
	—0.252	—0.252	+0.257	0.140	+0.049	+0.503	—0.102	—11.38
23.4272	+0.027	+0.028	—0.165	0.250	—0.507	—0.021	+0.013	+ 3.18
	—0.256	—0.267	+0.285	0.110	0.025	+0.445	—0.250	—10.69
25.5434	+0.413	+0.469	—0.423	0.305	0.361	—0.069	+0.086	+17.23
	—0.171	—0.194	+0.234	0.042	0.164	+0.170	—0.456	— 5.45
26.4523	+0.520	+0.611	—0.453	0.386	0.234	—0.078	+0.106	+22.18
	—0.105	—0.123	+0.183	0.040	—0.201	+0.015	—0.475	— 2.61
29.5334	+0.506	+0.664	—0.187	0.490	+0.273	—0.107	+0.099	+20.17
	+0.119	+0.156	+0.125	+0.132	—0.188	+0.395	—0.248	+ 5.90
Dec 4.6198	—0.401	+0.705	+0.209	+0.571	—0.026	+0.062	—0.130	+ 8.35
	0.059	0.104	0.193	0.030	+0.166	0.403	+0.318	— 2.29
7.5974	0.192	0.300	0.249	0.332	—0.314	0.001	—0.030	+ 3.96
	0.186	0.291	0.347	0.038	+0.051	+0.495	—0.188	2.20
8.5828	0.058	0.086	0.117	+0.290	—0.351	—0.022	+0.015	2.18
	—0.196	+0.292	+0.364	—0.003	0.006	+0.415	—0.338	2.76
9.5794	+0.084	—0.120	—0.026	+0.315	0.347	—0.044	+0.059	0.80
	—0.182	+0.260	+0.339	—0.042	—0.062	+0.285	—0.450	2.14
15.5784	+0.335	—0.344	0.237	+0.502	+0.211	—0.044	+0.106	+ 1.73
	0.096	0.099	0.237	0.071	—0.144	—0.576	—0.106	— 0.24
19.5685	0.010	0.008	0.075	+0.290	+0.432	+0.034	—0.031	+ 3.27
	+0.159	—0.121	0.343	—0.015	+0.024	—0.478	+0.444	— 5.32
26.5105	—0.382	+0.114	0.268	+0.534	—0.109	+0.053	—0.114	+ 7.79
1885	—0.096	0.029	+0.221	0.052	+0.015	+0.459	+0.220	0.02
Jan 2.5323	+0.356	+0.060	—0.084	+0.545	—0.145	—0.074	+0.133	0.36
	—0.059	—0.010	+0.193	—0.027	—0.165	—0.172	—0.483	1.59
8.5287	+0.123	+0.070	0.150	+0.308	+0.402	+0.010	+0.016	+ 2.47
	0.155	0.088	0.304	0.030	—0.034	—0.572	+0.283	— 3.83
9.5437	0.029	0.018	0.087	0.286	+0.424	+0.030	—0.021	+ 2.38
	+0.158	+0.100	0.341	0.006	0.013	—0.500	+0.405	— 5.07
10.5272	—0.065	—0.045	0.002	+0.302	0.419	+0.048	—0.056	+ 4.58
	+0.149	+0.105	+0.324	—0.038	0.058	—0.398	+0.496	— 5.18
12.4723	—0.238	—0.198	—0.086	+0.419	0.329	+0.073	—0.112	+ 8.81
	+0.104	+0.087	+0.248	—0.067	0.133	—0.131	+0.578	— 5.28
13.5043	—0.313	—0.282	—0.056	+0.497	0.244	+0.078	—0.131	+ 9.46
	+0.066	+0.059	+0.205	—0.055	+0.159	0.030	+0.560	— 4.40
17.6180	—0.322	—0.379	0.300	+0.448	—0.203	0.035	—0.086	+ 7.14
	—0.137	—0.161	+0.267	0.064	+0.116	+0.496	+0.075	2.15
21.5273	+0.156	+0.225	—0.094	+0.344	—0.316	—0.054	+0.076	0.57
	—0.161	—0.231	+0.304	—0.052	0.088	+0.213	—0.467	2.55
22.4991	+0.262	+0.393	—0.139	+0.432	0.255	—0.062	+0.106	1.02
	—0.121	—0.182	+0.247	—0.056	—0.128	—0.002	—0.502	3.05
29.4584	+0.144	+0.283	0.188	+0.312	+0.380	+0.003	+0.027	+ 1.14
1887	+0.149	+0.292	+0.321	+0.037	—0.046	—0.572	+0.229	— 2.19
Jan 18.5683	+0.300	—0.549	+0.353	+0.358	—0.203	—0.048	+0.140	— 6.51
	—0.054	+0.098	0.029	—0.176	—0.167	0.411	—0.412	+ 0.31
22.5185	+0.310	—0.485	0.423	+0.026	+0.189	0.035	+0.091	— 5.94
	0.092	0.143	0.100	—0.164	—0.142	0.618	0.140	0.81
24.5309	0.189	0.270	0.322	0.059	+0.341	0.014	0.027	3.47
	0.139	0.200	0.105	0.244	—0.071	0.499	+0.404	3.17
25.5538	0.100	0.136	0.267	0.024	+0.385	0.002	—0.009	3.08
	+0.151	—0.206	0.089	—0.281	—0.027	—0.384	+0.500	1.95
26.5482	—0.002	+0.003	0.233	+0.059	+0.400	+0.011	—0.044	0.21
	+0.152	—0.198	0.064	—0.299	0.018	—0.245	+0.557	— 1.91
27.5395	—0.113	+0.140	0.231	+0.169	0.383	+0.022	—0.075	+ 0.86
	+0.141	—0.174	0.037	—0.293	0.062	—0.087	+0.570	— 2.52
30.5067	—0.404	+0.417	0.415	+0.307	0.142	+0.041	—0.117	+ 4.87
	+0.023	—0.024	0.029	—0.161	0.143	+0.364	+0.314	+ 0.63
Feb 11.5254	0.337	0.078	0.436	+0.145	+0.074	—0.044	+0.118	— 0.61
	+0.052	—0.012	+0.079	—0.135	—0.166	—0.603	—0.050	+ 0.89

Gr. M.T.	a_0'	a_1'	b'	c'	d'	e'	f'	n
1887								″
Feb 12.5070	+0.311	−0.052	+0.420	+0.050	+0.168	−0.037	+0.096	− 0.27
	0.085	0.014	0.097	−0.156	−0.146	0.611	0.094	+ 0.58
13.5179	0.265	0.026	0.381	0.023	+0.255	0.027	0.067	0.15
	0.113	−0.011	0.107	−0.191	−0.116	−0.581	+0.236	+ 0.13
16.5511	0.017	+0.002	0.232	+0.044	+0.391	+0.009	−0.036	− 0.60
	+0.152	+0.016	0.070	−0.294	+0.009	−0.279	+0.531	0.24
22.5034	−0.413	−0.207	0.454	+0.108	−0.083	+0.032	−0.086	− 3.03
	0.081	0.040	0.090	−0.139	+0.125	0.472	0.000	+ 0.74
24.4956	0.251	0.159	0.326	0.024	−0.286	0.008	0.016	− 2.43
	−0.158	−0.100	0.121	−0.230	+0.051	+0.392	−0.065	− 4.32
27.4766	+0.103	+0.086	0.214	+0.247	−0.347	−0.031	+0.093	+ 1.74
	−0.139	−0.116	0.049	−0.270	0.091	0.018	−0.516	− 2.06
28.4567	+0.193	+0.173	0.250	+0.327	0.303	0.040	+0.116	+ 4.07
	−0.109	−0.098	0.031	−0.236	0.127	0.169	−0.521	− 2.87
Mar 1.4636	+0.262	+0.253	0.306	+0.357	0.234	0.046	+0.131	+ 5.33
	−0.073	−0.070	0.026	−0.193	0.154	0.310	−0.455	− 1.92
2.5082	+0.308	+0.319	0.364	+0.329	0.145	0.049	+0.136	+ 6.65
	−0.033	−0.034	0.034	−0.155	−0.170	−0.433	−0.351	− 1.50
10.5077	−0.058	−0.091	0.215	+0.112	+0.373	+0.018	−0.057	− 1.29
	+0.143	+0.224	0.018	−0.289	0.039	−0.172	+0.533	+ 2.96
11.4618	−0.160	−0.262	0.231	+0.213	0.342	+0.028	−0.082	− 4.54
	+0.126	+0.205	0.024	−0.270	0.077	−0.024	+0.527	+ 2.19
12.4541	−0.297	−0.447	0.283	+0.292	0.279	+0.035	−0.102	− 5.97
1888	+0.095	+0.160	+0.011	−0.229	+0.110	+0.130	+0.474	+ 2.02
Jan 18.5755	+0.348	−0.636	+0.430	−0.254	+0.005	−0.175	+0.077	+12.40
	0.040	0.073	0.018	0.151	−0.147	0.623	0.024	− 2.72
19.5802	0.335	0.590	0.395	0.339	+0.108	0.167	0.084	+11.42
	0.071	0.124	0.029	0.179	−0.130	0.600	0.125	+ 1.38
21.5613	0.240	0.390	0.281	0.378	+0.282	0.119	0.081	7.55
	+0.120	−0.196	0.021	0.248	−0.074	−0.439	+0.293	+ 1.42
30.5128	−0.347	+0.357	0.349	0.318	−0.231	+0.112	−0.072	− 8.19
	0.115	0.119	0.045	0.230	+0.073	0.414	0.238	4.90
Feb 1.5681	0.133	0.119	0.231	0.201	−0.377	0.035	0.054	4.13
	0.140	0.126	0.007	0.280	0.006	+0.153	0.379	5.69
2.5490	0.023	0.019	+0.228	0.091	0.400	−0.010	0.037	1.47
	−0.133	+0.110	−0.016	0.270	0.046	0.001	−0.399	− 5.33
8.5394	+0.346	−0.149	+0.434	0.222	0.015	0.175	+0.071	+ 1.65
	0.033	0.014	0.016	0.150	−0.152	0.617	−0.009	− 2.40
13.5122	0.068	0.007	+0.213	0.222	+0.365	0.045	+0.056	+ 0.62
	+0.142	0.014	−0.016	0.281	−0.004	−0.196	0.365	− 0.14
15.5036	−0.175	−0.006	+0.280	0.011	+0.335	+0.048	0.014	0.34
	+0.117	+0.004	−0.052	−0.228	0.074	0.135	0.333	0.71
16.6007	−0.305	−0.033	+0.370	+0.014	+0.256	0.093	0.022	1.90
	+0.077	+0.008	−0.045	−0.177	0.106	0.303	+0.254	0.12
18.5003	−0.430	−0.100	+0.464	0.164	0.040	0.136	−0.054	2.90
	−0.020	−0.005	+0.011	−0.144	+0.123	+0.477	+0.040	− 1.84

Gr. M.T.	a_0'	a_1'	b'	c'	d'	e'	f'	n
1888								
Feb 28.5319	+0.320	+0.289	−0.009	−0.091	−0.132	[illegible]	+0.056	− 2.53
	−0.007	−0.006	+0.003	0.141	−0.157	0.561	[illegible]	− 2.56
Mar 6.5035	−0.022	−0.029	+0.214	0.125	+0.361	[illegible]	[illegible]	[illegible]
	+0.138	+0.189	0.034	0.270	0.027	[illegible]	[illegible]	− 4.01
7.5045	−0.146	−0.209	+0.259	0.023	0.336	[illegible]	[illegible]	[illegible]
	+0.122	+0.174	0.050	−0.236	0.066	0.087	[illegible]	[illegible]
8.5058	−0.265	−0.398	+0.336	+0.020	0.275	0.079	[illegible]	[illegible]
	+0.089	+0.134	0.049	−0.189	0.097	0.244	+0.277	[illegible]
9.4967	−0.360	−0.564	+0.411	0.021	0.182	0.111	0.029	[illegible]
	+0.044	+0.070	0.029	0.151	+0.117	0.370	+0.185	[illegible]
14.4696	−0.181	−0.344	+0.239	0.238	−0.337	0.056	0.057	[illegible]
	0.138	0.262	0.021	0.274	+0.016	0.239	[illegible]	− 1.51
15.4806	0.071	0.140	+0.215	0.131	−0.375	0.014	[illegible]	0.79
	−0.137	−0.269	−0.004	−0.275	0.026	+0.025	0.372	0.59
17.5141	+0.127	+0.267	+0.271	+0.031	0.354	0.071	[illegible]	2.45
	−0.103	−0.217	−0.036	−0.220	0.099	0.206	[illegible]	[illegible]
18.5092	+0.203	+0.440	+0.324	+0.043	0.305	0.106	+0.014	[illegible]
1889	−0.077	−0.167	−0.036	−0.184	−0.126	[illegible]	[illegible]	− 2.28
Feb 21.6185	+0.238	−0.323	+0.420	−0.250	−0.243	−0.017	+0.046	[illegible]
	−0.024	+0.032	−0.126	0.016	0.078	0.573	0.118	1.27
26.5834	+0.329	−0.339	−0.094	0.344	[illegible]	[illegible]	+0.021	[illegible]
	+0.070	−0.072	[illegible]	0.053	−0.032	0.311	[illegible]	− 0.57
Mar 2.5673	−0.146	+0.111	+0.340	0.194	+0.236	[illegible]	[illegible]	+ 2.51
	+0.061	−0.047	−0.176	0.021	+0.037	[illegible]	[illegible]	[illegible]
8.5630	−0.290	+0.105	0.015	0.313	−0.205	[illegible]	0.012	+ 1.67
	0.066	0.024	0.131	0.058	[illegible]	0.213	0.288	[illegible]
9.5508	0.214	0.063	+0.046	0.264	−0.260	0.050	[illegible]	[illegible]
	0.071	0.021	−0.161	0.055	+0.007	0.068	[illegible]	[illegible]
11.4928	0.043	0.007	+0.088	0.191	[illegible]	[illegible]	+0.022	[illegible]
	−0.067	0.011	−0.191	0.037	0.023	0.219	0.298	[illegible]
15.5071	+0.281	+0.028	+0.432	0.280	0.200	0.024	+0.048	[illegible]
	−0.013	−0.091	−0.116	0.018	−0.063	[illegible]	0.071	[illegible]
23.5415	−0.113	−0.072	+0.292	0.187	[illegible]	0.008	0.028	[illegible]
	+0.069	+0.044	0.193	0.024	0.034	[illegible]	[illegible]	1.21
Apr 11.5428	0.183	0.348	0.110	0.241	+0.212	[illegible]	[illegible]	[illegible]
	0.088	0.167	−0.194	0.050	−0.007	0.067	[illegible]	[illegible]
12.4854	0.066	0.130	+0.015	0.192	+0.238	−0.028	0.013	[illegible]
	+0.087	+0.170	−0.212	0.040	+0.011	+0.007	+0.241	[illegible]
19.5203	−0.305	−0.743	+0.219	0.318	−0.164	0.051	0.027	+ 7.48
	0.062	0.150	0.073	0.057	+0.031	0.280	0.270	1.51
21.5246	0.160	0.410	+0.276	0.225	−0.268	0.042	[illegible]	[illegible]
	0.072	0.186	0.014	0.051	0.000	[illegible]	[illegible]	− 0.47
22.5509	0.074	0.194	+0.202	0.189	0.294	+0.032	+0.017	− 0.87
	−0.070	−0.184	+0.001	−0.041	−0.016	−0.135	[illegible]	+ 0.40

§5. NORMAL EQUATIONS AND THEIR SOLUTION.

The equations of condition at each opposition have been solved separately, giving rise thereby to the following nine sets of Normal Equations.

1875.

$$
\begin{array}{rrrrrrrcr}
+1.9653x & -0.4004z & -0.4558u & -0.2910v & -0.3540w & +1.0622t & +0.0385y & = & -8.3708 \\
-0.4004 & +1.7435 & +1.2501 & +0.4449 & +0.0723 & +0.2177 & -0.4415 & = & +7.1682 \\
-0.4558 & +1.2501 & +1.8766 & +0.2855 & -0.0237 & -0.2426 & -0.6475 & = & +11.9268 \\
-0.2910 & +0.4449 & +0.2855 & +1.5971 & +0.5077 & +0.3706 & +0.2780 & = & +1.5795 \\
-0.3540 & +0.0723 & -0.0237 & +0.5077 & +2.0654 & +0.5938 & -0.0845 & = & -2.5966 \\
+1.0622 & +0.2177 & -0.2426 & +0.3706 & +0.5938 & +3.2005 & +0.1275 & = & -17.6476 \\
+0.0385 & -0.4415 & -0.6475 & +0.2780 & -0.0845 & +0.1275 & +1.8052 & = & -20.9868 \\
 & & & & & & [nn] & = & 373.61
\end{array}
$$

1877.

$$
\begin{array}{rrrrrrrcr}
+1.2600x & +0.0833z & -0.4682u & +0.2222v & -0.1230w & +0.2559t & +0.6927y & = & +57.2255 \\
+0.0833 & +1.0572 & -0.8068 & +0.2319 & -0.0564 & +0.0132 & +0.0505 & = & +14.3677 \\
-0.4682 & -0.8068 & +0.9212 & -0.3683 & +0.1178 & -0.1177 & -0.1709 & = & -31.5717 \\
+0.2222 & +0.2319 & -0.3683 & +1.2862 & -0.0166 & -0.0015 & -0.3832 & = & +20.3925 \\
-0.1230 & -0.0564 & +0.1178 & -0.0166 & +1.6417 & +0.4643 & -0.0552 & = & +11.1851 \\
+0.2559 & +0.0132 & -0.1177 & -0.0015 & +0.4643 & +1.1925 & +0.0941 & = & +5.4368 \\
+0.6927 & +0.0505 & -0.1709 & -0.3832 & -0.0552 & +0.0941 & +1.4776 & = & +16.7264 \\
 & & & & & & [nn] & = & 3005.94
\end{array}
$$

1879.

$$\begin{array}{rrrrrrrcr}
+2.0078\,x & +0.4895\,z & +0.3551\,u & -0.1786\,v & -0.5501\,w & +0.2613\,t & -0.2508\,y & = & -21.6613 \\
+0.1895 & +0.8901 & +0.1018 & +0.1708 & -0.2651 & -0.1869 & +0.3291 & = & -\ 2.8912 \\
+0.3551 & +0.1018 & +2.6102 & +0.6681 & -0.0121 & +0.0648 & -0.6190 & = & -\ 6.1199 \\
-0.1786 & +0.1708 & +0.6684 & +1.7126 & -0.0351 & +0.0745 & +0.2510 & = & +\ 5.9067 \\
-0.5501 & -0.2651 & 0.0121 & -0.0351 & +1.8505 & +0.0471 & -0.0153 & = & +\ 0.8681 \\
+0.2613 & -0.1869 & +0.0648 & +0.0745 & +0.0471 & +1.8232 & -0.1429 & = & -13.1988 \\
-0.2508 & +0.3291 & -0.6190 & +0.2540 & -0.0153 & -0.1429 & +2.0506 & = & +\ 5.7820 \\
 & & & & & & [nn] & = & 320.72
\end{array}$$

1880.

$$\begin{array}{rrrrrrrcr}
+3.6757\,x & +0.6603\,z & +0.7931\,u & +0.6995\,v & -1.2519\,w & +0.3929\,t & +0.2330\,y & = & +\ 1.1428 \\
+0.6603 & +2.6925 & +2.5181 & +0.2997 & -0.2273 & +0.0109 & -0.8237 & = & -\ 3.2972 \\
+0.7931 & +2.5181 & +3.2342 & +0.3595 & -0.1491 & +0.3166 & -0.5513 & = & -\ 3\ 5201 \\
+0.6995 & +0.2997 & +0.3595 & +3.0651 & -0.1099 & +0.9771 & -0.8318 & = & +\ 7.5477 \\
-1.2519 & -0.2273 & -0.1194 & -0.1099 & +2.8861 & +0.2108 & +0.0178 & = & -\ 7.9406 \\
+0.3929 & +0.0109 & +0.3166 & +0.9771 & +0.2408 & +3.7894 & +0.2488 & = & -17.9969 \\
+0.2330 & -0.8237 & -0.5513 & -0.8318 & +0.0178 & +0.2488 & +3.2022 & = & -17.9908 \\
 & & & & & & [nn] & = & 260.12
\end{array}$$

1883-4.

$$\begin{array}{rrrrrrrcr}
+2.9966\,x & -0.0159\,z & -0.6885\,u & -0.1592\,v & -1.3491\,w & +1.0744\,t & -0.3561\,y & = & +83.3144 \\
-0\ 0459 & +2.0812 & -1.1794 & -0.0962 & +0.1673 & +0.3333 & -1.6326 & = & -27.8641 \\
-0.6885 & -1.1791 & +2.6193 & -0.1540 & +0.4345 & -0.1376 & +1.4021 & = & -\ 4.3985 \\
-0.1592 & -0.0962 & -0.1510 & +3.1612 & +0.2848 & +0.8543 & +0.3295 & = & -11.3596 \\
-1.3491 & +0.4673 & +0.4345 & +0.2848 & +2.3859 & -0.6802 & +0.2527 & = & -39.6932 \\
+1\ 0714 & +0.3333 & -0.1376 & +0.8513 & -0.6802 & +2.5939 & -0.2877 & = & +12.3036 \\
-0.3561 & -1.6326 & +1.4021 & +0.3295 & +0.2527 & -0.2877 & +3.0127 & = & +21.0297 \\
 & & & & & & [nn] & = & 2818.69
\end{array}$$

1884-5.

$$\begin{array}{rrrrrrrcr}
+1.3100\,x & -0.2978\,z & -0.2815\,u & +0.0389\,v & -1.0067\,w & +1.0037\,t & -0.0575\,y & = & -19.7404 \\
-0.2978 & +1.8618 & +0.5662 & +0.0889 & -0.1785 & +0.1952 & +0.4061 & = & +\ 2.2363 \\
-0.2815 & +0.5662 & +2.8653 & +0.2011 & +0.0723 & -0.0728 & +0.3748 & = & +28.8864 \\
+0.0389 & +0.0889 & +0\ 2011 & +1.8123 & +0.3592 & +0.3470 & -0.2384 & = & +\ 3.3694 \\
-1\ 0067 & -0.1785 & +0.0723 & +0.3592 & +2.8717 & -1.0815 & +0.0410 & = & +17.2571 \\
+1.0027 & +0.1952 & -0.0728 & +0.3470 & -1.0815 & +2.7323 & +0.1993 & = & -25.2298 \\
-0.0575 & +0.4061 & +0.3748 & -0.2384 & +0.0410 & +0.1993 & +1.8099 & = & -\ 0.6289 \\
 & & & & & & [nn] & = & 611.63
\end{array}$$

1887.

$$\begin{array}{rrrrrrrcr}
+1.5080\,x & +0.4303\,z & -0.0907\,u & -0.0879\,v & -0.6018\,w & +1.2387\,t & -0.1092\,y & = & +\ 2.6814 \\
+0\ 4303 & +2.2194 & +0.6709 & +0.5288 & -0.3698 & +0.3525 & -0.5615 & = & -\ 5.9650 \\
-0.0907 & +0.6709 & +1.8782 & +0.0632 & +0.8163 & -0.6515 & +0.1799 & = & +\ 5.2784 \\
-0.0879 & +0.5288 & +0.0632 & +1.8862 & +0.7931 & +0.2004 & -0.3213 & = & -\ 6.8497 \\
-0.6018 & -0.3698 & +0.8163 & +0.7931 & +3.0563 & -0.4304 & +0.2783 & = & +\ 1.4556 \\
+1.2387 & +0.3525 & -0.6515 & +0.2004 & -0.4304 & +3.5405 & +0.0066 & = & +\ 4.4858 \\
-0.1092 & -0.5615 & +0.1799 & -0.3213 & +0.2783 & +0.0066 & +1.7207 & = & +23.8330 \\
 & & & & & & [nn] & = & 371.21
\end{array}$$

1888.

$$\begin{array}{rrrrrrrcr}
+1.4926\,x & -0.2677\,z & -0.1280\,u & -0.1148\,v & -0.6723\,w & +0.7624\,t & +0.0651\,y & = & +11.4211 \\
-0.2677 & +2.0071 & -0.8088 & +0.1023 & -0.1029 & -0.0078 & -0.9315 & = & +12.7692 \\
-0.1280 & -0.8088 & +1.6858 & +0.0725 & +0.2811 & -0.0166 & +0.6141 & = & +\ 1.9703 \\
-0.1148 & +0.1023 & +0.0725 & +1.7873 & +0.6988 & +0.3489 & -0.5868 & = & +14.1152 \\
-0.6723 & -0.1029 & +0.2811 & +0.6988 & +2.8535 & -0.1092 & +0.4356 & = & -\ 5.9350 \\
+0.7621 & -0.0078 & -0.0166 & +0.3189 & -0.1092 & +1.6675 & +0.1878 & = & +\ 8.0264 \\
+0.0651 & -0.9315 & +0.6111 & -0.5868 & +0.4356 & +0.1878 & +2.4940 & = & -34.9175 \\
 & & & & & & [nn] & = & 766.38
\end{array}$$

1890.

$$\begin{array}{rrrrrrrcr}
+0.6289\,x & -0.0528\,z & +0.0499\,u & +0.1688\,v & -0.0551\,w & +0.2190\,t & +0.2016\,y & = & -12.0962 \\
-0.0528 & +1.0427 & -0.3939 & -0.2497 & +0.0493 & +0.0162 & -0.4886 & = & +\ 0.4035 \\
+0\ 0499 & -0.3939 & +0.8115 & +0.2465 & -0.0203 & +0.0289 & +0.3976 & = & +\ 7.5286 \\
+0.1688 & -0.2197 & +0.2165 & +0.7381 & +0.0175 & -0.0306 & +0.3909 & = & -\ 0.6920 \\
-0.0551 & +0.0493 & -0.0203 & +0.0175 & +1.2251 & +0.1105 & -0.0547 & = & +\ 3.6680 \\
+0.2490 & +0.0162 & +0.0289 & -0.0306 & +0.1105 & +0.7740 & +0.1753 & = & -\ 2.4491 \\
+0.2016 & -0.4886 & +0.3976 & +0.3909 & -0.0517 & +0.1753 & +1.3076 & = & -\ 5.6515 \\
 & & & & & & [nn] & = & 391.44
\end{array}$$

In solving the foregoing equations, the values of x, z, u, v, w, t, were obtained in terms of y from the first six of each set, the value of y then being found from the seventh.

1875.

$$\begin{array}{rclcrr} x &=& 2dE &=& +0''.2306 & +0.0856y \\ z &=& 4edP &=& +1.1308 & +0.1035 \\ u &=& 3de &=& +1.7928 & +0.3359 \\ v &=& 3dI &=& +1.0627 & -0.2810 \\ w &=& 2\sin JdN &=& +0.2012 & +0.1371 \\ t &=& 2dJ &=& -5.1652 & -0.0128 \end{array}$$

$$y = 15 \quad d\mu = -11.7053$$

1877.

$$\begin{array}{rclcrr} x &=& 2dE &=& +11''.5755 & -0.6984y \\ z &=& 4edP &=& +\ 0.7711 & -0.2115 \\ u &=& 4de &=& -10.8651 & -0.2115 \\ v &=& 3dI &=& +\ 5.8696 & +0.1019 \\ w &=& 2\sin JdN &=& -\ 0.9222 & -0.0257 \\ t &=& 3dJ &=& -\ 6.7543 & +0.0633 \end{array}$$

$$y = 60 \quad d\mu = -12.7829$$

1879.

$$\begin{array}{rclcrr} x &=& 2dE &=& -10''.3869 & +0.2021y \\ z &=& 2edP &=& +\ 0.5357 & -0.6092 \\ u &=& 4de &=& -\ 1.1198 & +0.3216 \\ v &=& 3dI &=& +\ 1.0444 & -0.0194 \\ w &=& 3\sin JdN &=& -\ 2.3857 & -0.0171 \\ t &=& 2dJ &=& -\ 5.6361 & -0.0226 \end{array}$$

$$y = 30 \quad d\mu = +0.7271$$

1880.

$$\begin{array}{rclcrr} x &=& 2dE &=& -0''.5198 & -0.1675y \\ z &=& 4edP &=& -2.8168 & +0.5030 \\ u &=& 3de &=& +1.2081 & -0.2057 \\ v &=& 2dI &=& +1.1636 & +0.3221 \\ w &=& 2\sin JdN &=& -2.1878 & -0.0278 \\ t &=& 2dJ &=& -5.7583 & -0.1178 \end{array}$$

$$y = 30 \quad d\mu = -5.5958$$

1883-4.

$$\begin{array}{rclcrr} x &=& 2dE &=& +30.1863 & -0.0010y \\ z &=& 3edP &=& -12.0254 & +0.7412 \\ u &=& 4de &=& +\ 0.2713 & 0.1682 \\ v &=& 2dI &=& -\ 1.0526 & 0.0616 \\ w &=& 2\sin JdN &=& +\ 1.2949 & -0.2223 \\ t &=& 2dJ &=& -\ 5.5131 & -0.0310 \end{array}$$

$$y = 15 \quad d\mu = +6.8012$$

1884-5.

$$\begin{array}{rclcrr} x &=& 3dE &=& -9''.5269 & -0.0110y \\ z &=& 3edP &=& -2.7019 & -0.1926 \\ u &=& 4de &=& +9.3796 & -0.1081 \\ v &=& 3dI &=& +2.2171 & +0.1962 \\ w &=& 2\sin JdN &=& -0.1375 & -0.0977 \\ t &=& 2dJ &=& -5.6351 & -0.1216 \end{array}$$

$$y = 15 \quad d\mu = -1.1369$$

1887.

$$\begin{array}{rclcrr} x &=& 3dE &=& +1''.0609 & +0.0511y \\ z &=& 5edP &=& -1.2132 & +0.2856 \\ u &=& 3de &=& +5.1118 & -0.2197 \\ v &=& 3dI &=& -2.7415 & +0.1251 \\ w &=& 2\sin JdN &=& -0.2179 & -0.0338 \\ t &=& 2dJ &=& +2.4129 & -0.1010 \end{array}$$

$$y = 45 \quad d\mu = +13.4897$$

1888.

$$\begin{array}{rclcrr} x &=& 3dE &=& +10.7691 & +0.0723y \\ z &=& 5edP &=& +\ 9.9230 & +0.3713 \\ u &=& 3de &=& +\ 6.6954 & -0.1619 \\ v &=& 3dI &=& +\ 8.9706 & +0.1575 \\ w &=& 2\sin JdN &=& -\ 2.1188 & -0.2278 \\ t &=& 3dJ &=& +\ 2.0126 & -0.2562 \end{array}$$

$$y = 45 \quad d\mu = -11.6229$$

1890.

$$\begin{array}{rclcrr} x &=& 3dE &=& -21.2071 & -0.0941y \\ z &=& 2edP &=& +\ 3.8895 & +0.2996 \\ u &=& 6de &=& +11.5605 & -0.2163 \\ v &=& 4dI &=& +\ 1.3728 & -0.3471 \\ w &=& 2\sin JdN &=& +\ 1.7556 & +0.0577 \\ t &=& 4dJ &=& +\ 2.9502 & -0.2162 \end{array}$$

$$y = 45 \quad d\mu = -5.7253$$

From these we obtain the following corrections to the assumed elements. Under each date are three sets of values, the first expressed in terms of $d\mu$, the second in which $d\mu = 0$, and the third in which $d\mu$ is given the value corresponding to the values of y given above.

1875.

dE	$= +0^\circ.0309$	$+\ 1.926\,d\mu$	dE	$+0^\circ\ 1'.9$	$\pm 0\ 12.2$	dE	$-0\ 6.2$	$\pm 0\ 3.2$
dP	$= +0.7569$	$+11.640$	dP	$+0\ 15.4$	$\pm 1\ 17.5$	dP	$-0\ 3.2$	$\pm 0\ 20.2$
dN	$= +0.2383$	$+26.898$	dN	$+0\ 14.3$	$\pm 1\ 33.9$	dN	$1\ 38.1$	$\pm 0\ 24.7$
dJ	$= -0.7316$	$-\ 0.962$	dJ	$-0\ 13.9$	$\pm 0\ 14.3$	dJ	$0\ 39.9$	$\pm 0\ 3.7$
dI	$= +0''.3543$	-15.743	dI	$+0''.354$	± 0.502	dI	$+1.451$	± 0.135
de	$= +0.0075$	$+\ 0.088$	de	$+0.0075$	± 0.0028	de	$+0.0013$	± 0.0008
				$d\mu = 0$		$d\mu$	0.06964	± 0.00224
							[illegible]	$= 13.9545$

1877.

$dE = +5.5657 - 20.953\,d\mu$	$dE = +5^\circ\ 33'.9 \quad \pm 0\ 16'.2$	$dE = +6\ 45'.6 \quad \pm 0\ 6'.2$
$dP = +0.5162 - 36.669$	$dP = +0\ 31.0 \quad \pm 2\ 18.6$	$dP = +2\ 36.5 \quad \pm 0\ 50.0$
$dN = -1.0768 - 6.731$	$dN = -1\ 1.6 \quad \pm 1\ 39.8$	$dN = -0\ 11.6 \quad \pm 0\ 35.7$
$dJ = -0.6028 + 1.267$	$dJ = -0\ 36.2 \quad \pm 0\ 9.1$	$dJ = -0\ 10.5 \quad \pm 0\ 3.3$
$dI = +1.9565 + 30.021$	$dI = +1''.956 \quad \pm 0''.531$	$dI = +0''.244 \quad \pm 0''.210$
$de = -0.0127 - 0.055$	$de = -0.0127 \quad \pm 0.0049$	$de = -0.0095 \quad \pm 0.0018$
	$d\mu = 0$	$d\mu = -0.05701 \quad \pm 0.00289$
		$[nn.7] = 20.0189$

1879.

$dE = -1.3905 + 3.036\,d\mu$	$dE = -1\ 23'.4 \quad \pm 0\ 3'.2$	$dE = -1^\circ\ 22'.2 \quad \pm 0^\circ\ 3'.2$
$dP = +0.8961 - 114.229$	$dP = +0\ 53.8 \quad \pm 0\ 59.7$	$dP = +0\ 9.3 \quad \pm 1\ 1.9$
$dN = -4.8585 - 1.519$	$dN = -1\ 51.5 \quad \pm 0\ 15.3$	$dN = -1\ 52.1 \quad \pm 0\ 15.0$
$dJ = -0.7545 - 0.339$	$dJ = -0\ 45.3 \quad \pm 0\ 2.7$	$dJ = -0\ 15.1 \quad \pm 0\ 2.6$
$dI = +0''.3481 - 1.814$	$dI = +0''.348 \quad \pm 0''.142$	$dI = +0''.336 \quad \pm 0''.139$
$de = -0.0013 + 0.042$	$de = -0.0013 \quad \pm 0.0003$	$de = -0.0011 \quad \pm 0.0001$
	$d\mu = 0$	$d\mu = +0.00649 \quad \pm 0^\circ.00293$
		$[nn.7] = 10.8778$

1880.

$dE = -0.0696 - 2.513\,d\mu$	$dE = -0^\circ\ 4'.2 \quad \pm 0\ 5'.5$	$dE = +0\ 3'.3 \quad \pm 0\ 2'.4$
$dP = -2.3819 + 17.158$	$dP = -2\ 22.9 \quad \pm 1\ 12.7$	$dP = -4\ 44.2 \quad \pm 0\ 30.8$
$dN = -2.9078 - 3.613$	$dN = -2\ 54.5 \quad \pm 0\ 51.9$	$dN = -2\ 43.5 \quad \pm 0\ 22.7$
$dJ = -0.7708 - 1.767$	$dJ = -0\ 46.2 \quad \pm 0\ 5.0$	$dJ = -0\ 41.0 \quad \pm 0\ 2.2$
$dI = +2''.2318 + 18.014$	$dI = +2''.232 \quad \pm 0''.349$	$dI = +1''.331 \quad \pm 0''.161$
$de = +0.0019 - 0.036$	$de = +0.0019 \quad \pm 0.0019$	$de = +0.0037 \quad \pm 0.0008$
	$d\mu = 0$	$d\mu = -0^\circ.04994 \quad \pm 0.00279$
		$[nn.7] = 18.2354$

1883-4.

$dE = +4^\circ.0410 - 0.022\,d\mu$	$dE = +4\ 2'.5 \quad \pm 0\ 6'.8$	$dE = +4\ 2'.4 \quad \pm 0\ 2'.2$
$dP = -10.7322 + 111.174$	$dP = -10\ 43.9 \quad \pm 0\ 56.9$	$dP = -6\ 14.0 \quad \pm 0\ 22.3$
$dN = +1.5117 - 43.712$	$dN = +1\ 30.9 \quad \pm 1\ 7.2$	$dN = -0\ 15.3 \quad \pm 0\ 22.7$
$dJ = -0.7380 - 0.696$	$dJ = -0\ 14.3 \quad \pm 0\ 7.5$	$dJ = -0\ 46.0 \quad \pm 0\ 2.4$
$dI = -0''.5263 - 5.173$	$dI = -0''.526 \quad \pm 0''.365$	$dI = -0''.736 \quad \pm 0''.119$
$de = +0.0003 - 0.033$	$de = +0.0003 \quad \pm 0.0011$	$de = -0.0010 \quad \pm 0.0004$
	$d\mu = 0$	$d\mu = +0^\circ.04047 \quad \pm 0^\circ.00184$
		$[nn.7] = 7.8776$

1884-5.

$dE = -0.8502 - 0.165\,d\mu$	$dE = -0\ 51'.0 \quad \pm 0\ 2'.7$	$dE = -0^\circ\ 50'.9 \quad \pm 0\ 2'.5$
$dP = -2.4113 - 28.890$	$dP = -2\ 24.7 \quad \pm 0\ 18.3$	$dP = -2\ 12.4 \quad \pm 0\ 16.9$
$dN = -0.1609 - 19.212$	$dN = -0\ 9.7 \quad \pm 0\ 22.0$	$dN = -0\ 1.5 \quad \pm 0\ 20.1$
$dJ = -0.7541 - 2.736$	$dJ = -0\ 45.3 \quad \pm 0\ 2.6$	$dJ = -0\ 44.1 \quad \pm 0\ 2.4$
$dI = +0''.7491 + 10.992$	$dI = +0''.719 \quad \pm 0''.111$	$dI = +0''.671 \quad \pm 0''.103$
$de = +0.0110 - 0.021$	$de = +0.0110 \quad \pm 0.0003$	$de = +0.0111 \quad \pm 0.0003$
	$d\mu = 0$	$d\mu = -0.00710 \quad \pm 0.00182$
		$[nn.7] = 8.9871$

1887.

$dE = +0.0947 + 0.819\,d\mu$	$dE = +0\ 5'.7 \quad \pm 0\ 9'.2$	$dE = +0^\circ\ 9'.6 \quad \pm 0\ 2'.4$
$dP = -1.8934 + 21.418$	$dP = -1\ 53.6 \quad \pm 0\ 42.8$	$dP = -0\ 10.5 \quad \pm 0\ 11.6$
$dN = -0.2874 - 7.480$	$dN = -0\ 17.2 \quad \pm 1\ 52.1$	$dN = -0\ 53.3 \quad \pm 0\ 29.1$
$dJ = +0.3270 - 2.272$	$dJ = +0\ 19.6 \quad \pm 0\ 10.4$	$dJ = +0\ 8.7 \quad \pm 0\ 2.7$
$dI = -0''.9138 + 7.010$	$dI = -0''.914 \quad \pm 0''.550$	$dI = -0''.351 \quad \pm 0''.144$
$de = +0.0084 - 0.058$	$de = +0.0084 \quad \pm 0.0028$	$de = +0.0038 \quad \pm 0.0007$
	$d\mu = 0$	$d\mu = +0^\circ.08026 \quad \pm 0.00249$
		$[nn.7] = 18.5639$

1888.

$dE = +0^\circ.9611 \quad + \ 1.084\,d\mu$
$dP = +4.4280 \quad +27.884$
$dN = -2.7908 \quad -50.434$
$dJ = -0.1796 \quad - \ 3.842$
$dA = +2''.9902 \quad +25.630$
$de = +0.0101 \quad - \ 0.043$

$dE = +0^\circ\ 57'.7 \quad \pm 0^\circ\ 12'.5$
$dP = +1\ \ 25.7 \quad \pm 0\ \ 49.1$
$dN = -2\ \ 17.1 \quad \pm 1\ \ 58.1$
$dJ = -0\ \ 10.8 \quad \pm 0\ \ 11.2$
$dA = +2''.990 \quad \pm 0''.612$
$de = +0.0104 \quad \pm 0.0031$
$d\mu = 0$

$dE = +0^\circ\ 52'.0 \quad \pm 0^\circ\ \ 3'.6$
$dP = +2\ \ \ 0.3 \quad \pm 0\ \ 15.0$
$dN = +1\ \ 35.8 \quad \pm 0\ \ 35.3$
$dJ = +0\ \ \ 9.3 \quad \pm 0\ \ \ 3.3$
$dA = +0''.760 \quad \pm 0''.192$
$de = +0.0142 \quad \pm 0.0009$
$d\mu = -0^\circ.08700 \quad \pm 0.00302$
$[nn\,7] = 30.6218$

1890.

$dE = -1^\circ.8927 \quad - \ 1.416\,d\mu$
$dP = +4.3390 \quad +56.170$
$dN = +2.3124 \quad +12.781$
$dJ = +0.1975 \quad - \ 2.433$
$dA = +0''.3432 \quad -14.583$
$de = +0.0090 \quad - \ 0.028$

$dE = -1^\circ\ 53'.6 \quad \pm 0^\circ\ \ 8'.0$
$dP = +1\ \ 20.3 \quad \pm 1\ \ 17.2$
$dN = +2\ \ 18.7 \quad \pm 1\ \ 14.9$
$dJ = +0\ \ 11.8 \quad \pm 0\ \ \ 5.2$
$dA = +0''.313 \quad \pm 0''.340$
$de = +0.0090 \quad \pm 0.0010$
$d\mu = 0$

$dE = -1^\circ\ 50'.7 \quad \pm 0^\circ\ \ 5'.8$
$dP = +2\ \ 25.5 \quad \pm 0\ \ 52.1$
$dN = +1\ \ 52.6 \quad \pm 0\ \ 19.5$
$dJ = +0\ \ 16.8 \quad \pm 0\ \ \ 3.4$
$dA = +0''.810 \quad \pm 0''.230$
$de = +0.0100 \quad \pm 0.0006$
$d\mu = -0.03406 \quad \pm 0.00130$
$[nn.7] = 19.2136$

In considering the second and third sets of corrections, we see that in all the oppositions, except 1879, the probable errors of the latter set are the smaller, therefore it has been decided to use this set, giving us the following corrected elements:

§6. Final Elements.

Epoch 1875, Oct. 0.0 Gr. M.T.

$E = 63^\circ\ \ 7'.2 \quad \pm 0^\circ\ \ 3'.2$
$P = 173\ \ 58.1 \quad \pm 0\ \ 20.2$
$N = 122\ \ 14.2 \quad \pm 0\ \ 21.7$
$J = 5\ \ 55.3 \quad \pm 0\ \ \ 3.7$
$A = 215''.451 \quad \pm 0''.135$
$e = 0.1013 \quad \pm 0.0008$
$\mu = 16^\circ.85024 \quad \pm 0.00224$

Epoch 1877, Nov. 0.0 Gr. M.T.

$E = 346^\circ\ 24'.8 \quad \pm 0^\circ\ \ 6'.2$
$P = 133\ \ 19.7 \quad \pm 0\ \ 50.0$
$N = 123\ \ 15.5 \quad \pm 0\ \ 35.7$
$J = 5\ \ 51.5 \quad \pm 0\ \ \ 3.3$
$A = 214''.244 \quad \pm 0''.210$
$e = 0.0905 \quad \pm 0.0018$
$\mu = 16.86284 \quad \pm 0.00289$

Epoch 1879, Nov. 0.0 Gr. M.T.

$E = 91^\circ\ 29'.5 \quad \pm 0^\circ\ \ 3'.2$
$P = 86\ \ 31.0 \quad \pm 1\ \ \ 1.9$
$N = 122\ \ \ 9.7 \quad \pm 0\ \ 15.0$
$J = 5\ \ 49.3 \quad \pm 0\ \ \ 2.6$
$A = 214''.336 \quad \pm 0''.139$
$e = 0.0789 \quad \pm 0.0004$
$\mu = 16.92637 \quad \pm 0.00293$

Epoch 1880, Nov. 0.0 Gr. M.T.

$E = 184^\circ\ \ 5'.8 \quad \pm 0^\circ\ \ 2'.4$
$P = 5\ 918.3 \quad \pm 0\ \ 30.8$
$N = 121\ \ 20.6 \quad \pm 0\ \ 22.7$
$J = 5\ \ 53.6 \quad \pm 0\ \ \ 2.2$
$A = 215''.331 \quad \pm 0''.161$
$e = 0.0837 \quad \pm 0.0008$
$\mu = 16.86994 \quad \pm 0.00279$

Epoch 1884, Jan. 0.0 Gr. M.T.

$E = 302^\circ\ 52'.1 \quad \pm 0^\circ\ \ 2'.2$
$P = 351\ \ 20.5 \quad \pm 0\ \ 22.3$
$N = 123\ \ 56.5 \quad \pm 0\ \ 22.7$
$J = 5\ \ 48.3 \quad \pm 0\ \ \ 2.4$
$A = 213''.264 \quad \pm 0''.119$
$e = 0.0990 \quad \pm 0.0001$
$\mu = 16^\circ.96035 \quad \pm 0.00184$

Epoch 1885, Jan. 0.0 Gr. M.T.

$E = 359^\circ\ 39'.1 \quad \pm 0^\circ\ \ 2'.5$
$P = 336\ \ 31.8 \quad \pm 01\ \ 6.9$
$N = 121\ \ 12.6 \quad \pm 02\ \ 0.1$
$J = 5\ \ 50.1 \quad \pm 0\ \ \ 2.1$
$A = 211''.671 \quad \pm 0''.103$
$e = 0.1111 \quad \pm 0.0003$
$\mu = 16.91278 \quad \pm 0.00182$

Epoch 1887, Feb. 15.0 Gr. M.T.

$E = 174^\circ\ 11'.6 \quad \pm 0^\circ\ \ 2'.1$
$P = 302\ \ \ 1.5 \quad \pm 0\ \ 11.6$
$N = 123\ \ 25.7 \quad \pm 0\ \ 29.1$
$J = 5\ \ 58.7 \quad \pm 0\ \ \ 2.7$
$A = 213''.649 \quad \pm 0''.144$
$e = 0.1238 \quad \pm 0.0007$
$\mu = 17.00011 \quad \pm 0.00249$

Epoch 1888, Feb. 15.0 Gr. M.T

$E = 235^\circ\ \ 8'.0 \quad \pm 0^\circ\ \ 3'.6$
$p = 288\ \ 16.3 \quad \pm 0\ \ 15.0$
$N = 125\ \ 51.8 \quad \pm 0\ \ 35.3$
$J = 5\ \ 59.3 \quad \pm 0\ \ \ 3.3$
$A = 214''.760 \quad \pm 0''.192$
$e = 0.1342 \quad \pm 0.0009$
$\mu = 16.83288 \quad \pm 0.00302$

Epoch 1890, Mar. 14.0 Gr. M.T.

$E = 91^\circ\ 52'.3 \quad \pm 0^\circ\ \ 5'.8$
$P = 256\ \ \ 8.5 \quad \pm 0\ \ 52.1$
$N = 126\ \ 11.6 \quad \pm 0\ \ 19.5$
$J = 6\ \ \ 6.8 \quad \pm 0\ \ \ 3.4$
$A = 214''.840 \quad \pm 0''.230$
$e = 0.1300 \quad \pm 0.0006$
$\mu = 16.88582 \quad \pm 0.00130$

We shall now proceed to deduce from these nine sets of elements, their general values referred to the epoch 1884.0. In combining them the values of the eccentricity were given weights of the form $\pm N \sin(S-P)$, and the values of the longitude of perisaturnium, of the form $\pm N \cos(S-P)$, where N is taken proportional to the number of observations. S is the longitude of *Saturn*, and P the longitude of the perisaturnium of *Hyperion*.

Perisaturnium.

The value of the longitude of perisaturnium was assumed to be of the form

$$P_t = \Delta P \cdot t + s_1 \sin \Pi + s_2 \sin 2\Pi + s_3 \sin 3\Pi$$

where Π is the mean elongation of the perisaturnia of *Titan* and *Hyperion*.

Each of the nine values of the longitude gave us one equa-

tion whose form was that of the above expression equal to n. Solving these nine equations by the method of least squares, the following value was obtained.

$$\begin{aligned} P &= 8.46 \pm 0.53 - (18.442 \pm 0.106)t \\ &\quad + (11.10 \pm 0.86)\sin \Pi - (1.40 \pm 0.52)\sin 2\Pi \\ &\quad + (1.11 \pm 0.46)\sin 3\Pi \\ \Pi &= 263.54 + 18.942t \end{aligned}$$

t = time in years from 1884.0.

Since Π is a function of P the final values were obtained only after a series of approximations.

The following table gives the observed and computed values of P with the residuals, for the nine epochs of observation.

Date	Π	P obs.	P(comp.)	O — C	Wt.
1875.75	107.27	173.97	171.52	—0.55	8
1877.83	146.67	133.33	132.55	+0.78	6
1879.83	181.55	86.52	83.71	+2.78	2
1880.83	203.49	59.30	59.10	+0.20	8
1881.00	263.54	351.34	351.89	—3.55	2
1885.00	282.48	336.53	337.41	—0.91	2
1887.13	322.83	302.03	302.36	—0.33	10
1888.13	341.77	288.27	287.71	+0.56	10
1890.20	20.98	256.11	259.33	—3.19	2

Eccentricity.

From the nine values of the eccentricity given above was deduced the mean value

$$\begin{aligned} e &= 0.1056 \pm 0.0008 + (0.0258 \pm 0.0012)\cos \Pi \\ &\quad + (0.0008 \pm 0.0009)\cos 2\Pi \end{aligned}$$

The following table is similar to the one given under perisaturnium.

Date	e(obs.)	e(comp.)	O — C	Wt.
1875.75	0.1013	0.0972	+0.0041	5
1877.83	0.0905	0.0843	+0.0062	5
1879.83	0.0789	0.0807	—0.0018	9
1880.83	0.0837	0.0821	+0.0013	5
1884.00	0.0990	0.1019	—0.0029	8
1885.00	0.1111	0.1105	+0.0006	8
1887.13	0.1238	0.1264	—0.0026	2
1888.13	0.1342	0.1307	+0.0035	3
1890.20	0.1300	0.1303	—0.0003	6

Mean Longitude.

In attempting to combine the values of the mean longitude, it was found that the perturbations were not a function of the mean elongation of the perisaturnia of *Hyperion* and *Titan* as in the case of the longitude of perisaturnium and of the eccentricity, but had a much shorter period, one, in fact, of less than two years. The complete perturbation can be very satisfactorily expressed in a single term of period 639.5 days.

The following value was obtained:

$$\begin{aligned} E &= 295.92 \pm 0.03 + (16.92006 \pm 0.00001)t \\ &\quad + (9.05 \pm 0.03)\sin\left[48.07 \pm 0.23 + \frac{360}{639.5}t\right] \end{aligned}$$

t = no. of days from Jan. 0.0, 1884.

The following table shows how well this value satisfies the observations.

Date	E obs.	E(comp.)	O — C
1875 Oct. 0.0	63.12	63.20	—0.08
1877 Nov. 0.0	316.41	316.09	+0.32
1879 Nov. 0.0	91.19	91.51	—0.05
1880 Nov. 0.0	184.10	184.37	—0.27
1881 Jan. 0.0	302.87	302.65	+0.22
1885 Jan. 0.0	359.65	359.96	—0.31
1887 Feb. 15.0	171.21	171.24	—0.03
1888 Feb. 15.0	235.13	235.01	+0.12
1890 Mar. 14.0	91.87	91.79	+0.08

From this value of the mean longitude we obtain for the mean motion,

$$n = 16.92006 + 0.08892\cos\left[48.07 + \frac{360^\circ}{639.5}t\right]$$

The following table gives the values of the mean motion as computed for the epoch of the elements, 30 days before, and 30 days following, exhibiting the great change that occurs in this element during two months of a single opposition, together with the values derived from observations.

t	$t - 30^{\mathrm{d}}$	t	$t + 30^{\mathrm{d}}$	t(obs.)
1875 Oct. 0.0	16.85776	16.84201	16.83300	16.85024
1877 Nov. 0.0	16.83849	16.85228	16.87193	16.86284
1879 Nov. 0.0	16.90215	16.92203	16.94778	16.92637
1880 Nov. 0.0	16.90398	16.87926	16.85807	16.86994
1881 Jan. 0.0	16.99614	16.97948	16.95770	16.96035
1885 Jan. 0.0	16.87192	16.89571	16.92161	16.91278
1887 Feb. 15.0	16.98188	16.99779	17.00698	17.00014
1888 Feb. 15.0	16.83677	16.83132*	16.83354	16.83288
1890 Mar. 14.0	16.85856	16.87987	16.90465	16.88582

* The minimum value 16.83114 was reached between the dates Feb. 15.0 and Mar. 16.0.

As the constant value 16.91988 was used in forming all the equations of condition it will be necessary to investigate what effect this large perturbation will have upon their solution before proceeding further.

§7. The Libration of the Angle V.

Adopting Struve's value for the mean longitude of *Titan*, referred to 1884.0

$$E' = 91^\circ.59 + 22^\circ.57701t$$

the value of the angle $V = 4E - 3E' - P$, which at

conjunction of the satellites is equal to the mean anomaly of *Hyperion*, is

$$V^* = 180^\circ.45 + 36^\circ.20 \sin\left[48^\circ.07 + \frac{360}{639.5}\right] t$$
$$-14^\circ.40 \sin \Pi + 1^\circ.40 \sin 2\Pi - 1^\circ.11 \sin 3\Pi$$
$$\Pi = 263^\circ.54 + 18^\circ.942\, T$$

t = no. of days from 1884, Jan. 0.0.
T = no. of years from 1884.0.

Newcomb first called attention to this angle, and showed that it librated about 180° as a mean value. The amount of this libration can only be determined from the observations themselves. Struve found the value of the libration of short period, *A.N.* 3060, with which the value in the present paper very closely agrees. His residuals amounting to 16° in 1884.0 nearly disappear through the introduction of the librations of longer period.

The following table gives the comparison with observations.

Date	E	V obs	V comp	O − C
1875 Oct. 0.0	84.49	185.04	183.89	+1.15
1877 Nov. 0.0	8.17	147.77	147.72	+0.05
1879 Nov. 0.0	289.39	113.27	115.88	−2.61
1880 Nov. 0.0	272.57	219.39	220.44	−1.05
1884 Jan. 0.0	91.59	225.37	220.95	+4.42
1885 Jan. 0.0	71.78	157.73	158.21	−0.48
1887 Feb. 15.0	311.54	171.19	171.25	−0.06
1888 Feb. 15.0	275.15	186.80	187.30	−0.50
1890 Mar. 14.0	108.52	115.78	112.95	+2.83

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* The secular term is omitted, as it amounts to only about 1° in ten years, a quantity within the probable errors of our data.

COMET *a* 1892.

The comet 1892 II = *a* 1890 was rediscovered at Nice 1892 Jan. 6, and through an inadvertence was entered in our record as *a* 1892. The comet to which this notation belongs is that discovered by Swift, March 7, and erroneously designated as *b* 1892 on page 144. The error is corrected in the present number.

OBSERVATIONS OF COMET *a* 1892 (SWIFT),

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 9.6-INCH EQUATORIAL.

By Prof. E. FRISBY.

[Communicated by the Superintendent.]

1892 Washington M.T.	*	No. Comp.	☌ − * $\Delta\alpha$	☌ − * $\Delta\delta$	☌'s apparent α	☌'s apparent δ	log $p\Delta$	
d h m s			m s	′ ″	h m s	° ′ ″		
Mar. 11 17 37 57	1	3 , 1	−0 55.74	−3 29.7	19 22 14.80	−27 15 56.9	n9.521	0.874
13 17 3 12.2	2	20 , 4	+1 20.64	−22 34.9	19 31 27.86	−25 29 58.7	n9.552	0.852
21 17 13 21.0	3	12 , 3	−0 23.14	+16 10.4	20 7 23.40	17 43 34.7	n9.5204	0.8322
24 15 57 4.3	4	20 , 4	+2 28.25	−4 45.2	20 19 51.15	−14 41 3.0	n9.6245	0.7492

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	19 23 11.33	−0.79	−27 12 21.1	−6.1	Stone 10537
2	19 30 7.98	−0.76	−25 7 17.0	−6.8	Stone 10584
3	20 7 17.28	−0.74	−18 0 6.6	−8.5	Lamont 1120
4	20 17 23.57	−0.64	−14 36 6.9	−10.9	Grant 5095

OBSERVATIONS OF COMETS,

MADE AT THE HAVERFORD COLLEGE OBSERVATORY WITH THE 10-INCH EQUATORIAL.

By Prof. F. P. LEAVENWORTH and Mr. W. H. COLLINS.

1892 Haverford M.T.	*	No. Comp.	☌ − * $\Delta\alpha$	☌ − * $\Delta\delta$	☌'s apparent α	☌'s apparent δ	log $p\Delta$		Obs.
			Periodic Comet of Wolf 1891 II						
d h m s			m s	′ ″	h m s	° ′ ″			
Feb. 17 9 23 55	1	9 , 5	−0 16.52	+7 29.8	4 15 5.44	6 59 26.0	9.434	0.758	C
			Comet *a* 1892 (Swift)						
Mar. 20 16 54 16	2	8 , 5	−0 30.66	5 35.0	20 2 58.11	18 45 22.9	9.548	0.8[illegible]4	L

Mean Places for 1892.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 15 22.27	−0.31	−7 7 0.9	+5.1	Schjellerup 1556
2	20 3 28.82	−0.05	−18 39 12.0	−5.9	Yarnall (F) 8915

OBSERVATIONS OF COMET *a* 1892 (*SWIFT*),

MADE WITH THE 15-INCH EQUATORIAL OF THE HARVARD COLLEGE OBSERVATORY,

BY O. C. WENDELL, ASSISTANT.

[Communicated by Prof. EDWARD C. PICKERING, Director.]

1892 Cambridge M.T.	✱	No. Comp.	☄ — ✱		☄'s apparent		log *p*Δ	
			Δα	Δδ	α	δ	for α	for δ
d h m s			m s	′ ″	h m s	° ′ ″		
Mar. 9 17 2 57	1	1	−3 36.64	+15 7.3	19 12 31.19	−29 1 5.8	*n*9.538	0.874
11 16 38 57	2	7	−1 11.26	− 6 28.9	19 21 59.21	−27 18 56.0	*n*9.576	0.857

Mean Places for 1892.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	19 16 8.67	−0.81	−29 16 7.7	−5.4	Gould's G.C. 26521
2	19 23 11.27	−0.80	−27 12 21.0	−6.1	" 26682

FILAR-MICROMETER OBSERVATIONS OF COMET *a* 1892 (*SWIFT*),

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY,

BY E. E. BARNARD.

1892 Mt. Hamilton M.T.	✱	No. Comp.	☄ — ✱		☄'s apparent		log *p*Δ	
			Δα	Δδ	α	δ	for α	for δ
d h m s			m s	′ ″	h m s	° ′ ″		
Mar. 7 16 50 51	1	5 , 2	−0 8.59	−22 4.1	19 3 25.28	−30 32 51.0	*n*9.474	0.879
8 16 22 13	2	2	. . . .	− 4 26.5	. . . . .	−29 15 9.6	. . .	0.839
16 35 11	2	1	+3 48.75	. . . .	19 8 16.13	. . . . . .	*n*9.259	. . .
9 16 21 21	3	12 , 4	+0 59.13	− 4 57.7	. . . . .	. . . . . .	*n*9.562	0.856
15 17 31 36	4	6 , 1	+0 12.20	+ 8 21.8	19 11 23.97	−23 30 24.5	*n*9.435	0.861

Δα measured direct, Mar. 7.

Mean Places for 1892.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	19 3 34.76	−0.89	−30 10 41.9	−5.0	Yarnall (F) 8329
2	19 4 28.19	−0.81	−29 40 38.0	−5.1	Yarnall (F) 8335
3	. . . .	−0.79	. . . .	−5.8	. . . .
4	19 10 42.53	−0.76	−23 38 39.1	−7.2	Gould Z.C. 1681

After an absence from the observatory of nearly two months, I returned on March 7, and the telegram announcing the discovery of this comet was received that day.

Looking approximately in the direction of the reported position of the comet on the morning of the 8th, before pointing the telescope on its place, it was seen at once with the naked eye, as a large, hazy star of the 5^{M} or 6^{M}.

In the finder (3¼-in.) the head was very bright, with a faint tail preceding.

In the 12-inch, the head was large and round, and about 8′ in diameter. In the center was a small nucleus of 11^{M}; this seemed to have a sensible diameter and was not stellar.

On the morning of the 10th, the comet was conspicuous with the naked eye. It was somewhat more noticeable and brighter than the trifid nebula, but smaller, to the eye alone. It was considerably brighter than the naked eye cluster N. G. C. 6444. It appeared about as large to the eye as the *Orion* nebula would, but much brighter. It would not have been missed even in a casual glance at the south-east heavens.

On the morning of March 16 it was quite easily seen with the naked eye, though the moon was nearly full.

At the observation of March 7, the Δδ was too great to measure direct. A $12^{M}.5$ star was therefore compared with the comet, and this in turn was referred to the YARNALL star.

The comparison-star of March 9 has not been identified with certainty. It was about 8^{M}. The approximate place was about $19^{h}\ 12^{m}\ 8^{s}$, $-28°\ 49'$ (1892.0.)

On the 16th, daylight prevented the identification of the comparison-star with certainty. One pointing seemed to identify it with GOULD Z. 1681, which star I have assumed it to be. Cloudy weather since has prevented a verification of this. It was noted as 8^{M}.

Mt. Hamilton, 1892 *March* 18.

OBSERVATIONS OF THE COMET *a* 1892 (*SWIFT*),

MADE AT THE OBSERVATORY OF THE STATE UNIVERSITY, COLUMBIA, MO., WITH THE $7\frac{1}{2}$-INCH EQUATORIAL.

By MILTON UPDEGRAFF.

1892 Columbia M.T.	∗	No. Comp.	☄ — ∗ $\Delta\alpha$	☄ — ∗ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
Mar. 10ᵈ 17ʰ 38ᵐ 11ˢ.6	1	5	— 2ˢ.41	—1′ 23″.3	19ʰ 17ᵐ 42ˢ.96	—28° 5′ 55″.0	n9.4771	0.8769
11 17 13 39.1	2	7	—47.54	—2 21.2	19 22 22.99	—27 14 48.3	n9.5356	0.8622
12 17 14 2.8	3	8	+51.02	—5 59.5	19 27 5.99	—26 21 32.1	n9.5330	0.8599

Mean Places for 1892.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
1	19ʰ 17ᵐ 46ˢ.17	—0ˢ.80	—28° 4′ 25″.9	—5″.8	½ (2 Arg. Gen. Cat. + Yarnall)
2	19 23 11.32	—0.79	—27 12 21.0	—6.1	½ (2 Arg. Gen. Cat. + Yarnall)
3	19 26 15.75	—0.78	—26 15 26.2	—6.4	Arg. Gen. Cat., 4 obs.

These observations were made at a zenith-distance of 75°. The corrections for differential refraction have been applied. The position of this observatory is, $\lambda = 6^h\ 9^m\ 18^s.2$, $\varphi = +38°\ 56'\ 51''.6$

RING-MICROMETER OBSERVATIONS OF COMET *a* 1892 (*SWIFT*),

MADE AT COLUMBIA COLLEGE OBSERVATORY, WITH THE 13-INCH RUTHERFURD EQUATORIAL.

By J. K. REES, AND HAROLD JACOBY.

1892 Col. Coll. M.T.	∗	No. Comp.	☄ — ∗ $\Delta\alpha$	☄ — ∗ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ	Obs.
Mar. 20ᵈ 17ʰ 13ᵐ 56ˢ	1	1	—27ˢ.65	—5′ 1″.3	20ʰ 3ᵐ 0ˢ.49	—18° 44′ 50″.5	n9.507	0.846	Jac.
17 16 52	1	1	—27.28	—4 52.5	20 3 0.86	—18 44 41.7	n9.501	0.818	Rees

Mean Place for 1892.0 of Comparison-Star.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
1	20ʰ 3ᵐ 28ˢ.84	—0ˢ.70	—18° 39′ 40″.8	—8″.4	⅓(Y.8915 + Munich 23176 + Oelz. Arg. 20274)

The definition and steadiness of the images were very good. The comet showed a well-defined nucleus admitting of accurate observation.

ORBIT AND EPHEMERIS OF COMET *a* 1892 (*SWIFT*),

By Rev. G. M. SEARLE.

The considerable discordance of the middle place, in the orbit first computed for this comet, giving some suspicion of departure from a parabola, I undertook an unrestricted calculation from BARNARD's observation of March 8, FRISBY's of March 13, and one which I made on March 21. The indications pointing, however, in this calculation, to a very decided hyperbola, I computed a new parabola from my own observations of March 10 and 21, with FRISBY's of March 13. These gave the following orbit, very decidedly different from that before obtained:

$$\begin{aligned} T &= \text{April } 2.2832 \quad \text{Gr. M.T.} \\ \omega &= 19°\ \ 0'\ 31'' \\ \Omega &= 239\ \ 41\ \ 33 \quad 1892.0 \\ i &= 36\ \ 38\ \ 52 \\ \log q &= 0.013210 \end{aligned}$$

There is still, however, considerable discordance of the middle place, probably partly owing to the approximation not having been carried far enough. The residuals are as follows: (O − C), λ = 2′ 55″, β = —18″. The indication from these would be an elliptic orbit; but there is probably an error in some one of the observations which have been used, and it cannot be certainly known as yet in which set it is to be found. This orbit gives the following ephemeris, for Greenwich midnight, which, though it can hardly be accurate, will probably be better than the previous one.

	α	δ	log Δ	Br
March 30.5	20ʰ 11ᵐ.9	8° 58′	0.0180	1.21
April 3.5	20 56.9	1 54	.0229	1.21
7.5	21 11.3	0 57	.0297	1.17
11.5	21 25.0	+2 54	0.0381	1.11

COMET *b* 1892.

The periodic comet of WINNECKE was rediscovered at Vienna, in the position

1892 March 18.1011 Greenw. M.T. $\alpha = 12^h\ 43^m\ 27^s.5$, $\delta = +30°\ 35'\ 38''$

An ephemeris by Dr. v. HALKDEL may be found in No. 3062 of the *Astronomische Nachrichten*.

COMET *c* 1892 (*DENNING*).

A faint comet was discovered by DENNING, at Bristol, England,

1892 March 18.5 Greenw. M.T. $\alpha = 22^h\ 11^m$ $\delta = +59°$. Daily motion 0° 50′ north preceding.

It was observed by SPITALER at Vienna March 19.4338 Greenw. M.T., $\alpha = 22°\ 16'\ 47''.1$, $\delta = +59°\ 17'\ 13''$

FILAR-MICROMETER OBSERVATIONS OF COMET *c* 1892 (*DENNING*),

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY,

BY E. E. BARNARD.

1892 Mt. Hamilton M.T.	✱	No. Comp.	☄ — ✱		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
d h m s			m s	′ ″	h m s	° ′ ″		
Mar. 20 13 21 13	1	12 , 1	−1 28.17	−3 18.7	22 55 12.81	+59 33 28.9	*n*9.737	0.881
21 12 58 17	1	3	. . . . . .	+6 21.0	. . . .	+59 13 8.5	. . .	0.895
13 8 22	1	6	+1 36.88	. . . . .	23 1 17.91	. . . .	*n*9.695	. . .

Mean Place for 1892.0 of Comparison-Star.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
1	h m s 22 57 11.15	s (−3.11) (−3.12)	° ′ ″ +59 36 59.0	″ (−11.4) (−11.5)	Krueger's Zones

Comet about 12½ mag. 1′ diameter. Indefinite, brightening near middle.

Mt. Hamilton, 1892 *March* 22.

NEW ASTEROIDS.

The three following are announced by telegraph:

WOLF, March 18.4018 Greenw. M.T. $\alpha = 11^h\ 6^m\ 40^s.6$ $\delta = +4°\ 11'\ 19''$, 12^M photogr.
PALISA, 19.3900 $13^h\ 27^m\ 0^s$ $+9°\ 55'\ 9''$, 11^M
Daily motion, -64^s in α and 3′ southward.
CHARLOIS, March 22.519 Greenw. M.T. $\alpha = 12^h\ 41^m\ 13^s.3$ $\delta = -7°\ 15'\ 26''$, 13^M
Daily motion, -60^s in α and 5′ northward.

These would, in their natural sequence, be nos. 326, 327 and 328; PALISA's of Feb. 25 being no. 325 (see p. 136).

Mr. BERBERICH, however, has found, after more precise computation, that the Vienna observation of Jan. 20 (p.112) was not of WOLF's asteroid of Nov. 28, but of no. 30, *Urania*.

Prof. KRUEGER proposes that, since there are no other observations of the photographically determined planet of Nov. 28, no number be assigned to it; and has carried out this proposition by giving, in the *Astron. Nachrichten*, the number 324 to PALISA's of Feb. 25.

Any permanent discordance in the notation would be lamentable, and yet it seems highly improbable that WOLF's photographic discovery should not soon be confirmed. The question thus arises whether a single observation, photographic or visual, if not promptly confirmed, shall be regarded as a discovery, and entitle the planet to its corresponding number. For the present, no numerical notation is here employed, in the hope that some decision may soon be reached on this point.

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PROVISIONAL RESULTS OF A DETERMINATION OF THE CONSTANT OF ABERRATION,

BY GEORGE C. COMSTOCK.

The observations which are discussed provisionally in the present paper were made with the six-inch CLARK equatorial telescope of the Washburn Observatory, during the years 1890-91. In accordance with the original programme the observations should have been brought to a close in 1891, but, the weather during the spring of that year having been very unfavorable to astronomical observation, I have thought it advisable to prolong the series through the present spring, in order to obtain a symmetrical distribution of observations throughout the year. In the mean time, in order to ascertain the quality and probable outcome of the work, I have made a discussion of the data already available without resorting to those niceties of computation which will find their appropriate place in a definitive discussion, and have obtained the following results, which, although properly designated provisional, may be considered as representing the definitive results within very narrow limits.

The method adopted for the investigation of the aberration is a modified form of that proposed by Mr. LOEWY, which is now so familiar that I shall not here attempt any description, either of apparatus or the details of observation, further than is necessary for an understanding of those matters in respect of which I have not followed Mr. LOEWY's methods. The essential feature of the method devised by Mr. LOEWY is the introduction of reflecting surfaces in front of the objective of a telescope, by means of which images of different portions of the heavens are simultaneously produced in the focal plane of the objective. By means of a micrometer, the apparent distance between the images of two stars thus produced may be measured, and the angular distance between the stars determined from a simple relation involving the measured quantity and the angle included by the reflecting surfaces. It is obvious that great difficulties would attend the determination of this angle; and Mr. LOEWY avoids these difficulties by measuring the distances of two pairs of stars and taking the difference of these distances, thus eliminating the angle between the mirrors and obtaining as the absolute term of his equations the difference between two measured distances. It has seemed to be advantageous to place before the objective three reflecting surfaces instead of two, making approximately equal angles among themselves, and to employ successively each pair of surfaces in measuring the distance between two given stars. If the normals to these surfaces all lie in the plane passing through the two stars and the earth, the mean of the three diedral angles formed by the surfaces will be exactly 120°; and, by taking the mean of the results furnished by the three pairs of surfaces, the distance between a pair of stars may be determined independently of the angles between the mirrors. In practice there is always required a small correction-term, depending upon the squares of the errors of adjustment of the mirrors, but in the present series of observations this correction, which I represent by K, has never amounted to 0″.6. Since the error of adjustment of the mirrors admits of determination within a fraction of a minute of arc, the quantity K is always known within 0″.01 or 0″.02. This substitution of three mirrors in place of two has determined the whole subsequent course of the observations, and is the primary source of difference between the methods which I have adopted and those of Mr. LOEWY.

If we represent by d the distance between the images of the stars as measured with the micrometer, by Δ the angle subtended at the earth by the stars, and by R the effect of refraction in changing the true Δ into an apparent Δ, we shall have the following relation among the quantities

$$\Delta = 120° + K + d + R$$

an equation which is fundamental to this method of research. The first term of the second member of this equation involves the implicit assumption of a considerable degree of stability in the adjustment of the mirrors; since, if a change in their relative position occurs during the progress of an observation, the mean of the angles will not in general be 120°. I wish, however, to emphasize the statements that the adjustments of the mirrors have, throughout the whole series of observations, exhibited a high degree of stability, and that

the observations have in general been so arranged that any uniformly progressive change in the adjustments of the mirrors will be eliminated from the result of each observation. The sole condition in regard to stability which the mirrors are required to fulfil is that, during an interval of time whose average duration is about twenty minutes, any changes which occur in their relative position shall be proportional to the time.

The appearance of the term in R indicates that the refraction will play an important part in this investigation, and in this respect the methods of Mr. Loewy possess a certain advantage over those which I have adopted, since all but a very minute part of the refraction is eliminated from each of his individual results. Its retention in my observations has imposed a considerable additional burden in the reduction of the work, but has enabled me to make a special investigation of the refraction without, I think, appreciably affecting the precision of the aberration-results.

The values of the refraction, with which the observations have been reduced, are those furnished by the Pulkowa tables. The temperature determinations, which serve as one of the arguments of the table, were made by whirling a thermometer in the open air just outside the light wooden building which shelters the telescope. A thermometer thus exposed is subject to at least two serious sources of error: radiation of heat from the person of the observer to the thermometer, and radiation from the thermometer to the sky: and it will readily be seen that not only do these causes produce effects of opposite sign, but that their relative efficiencies vary in opposite directions as the temperature changes, the former cause having its maximum effects, and the latter its minimum, at extreme low temperatures. It is therefore *a priori* probable that the temperatures with which the refractions were computed are affected with systematic errors depending upon the temperature itself, in such a manner that the indications of the thermometer are relatively too high at low temperatures and too low at high temperatures.

To control this, and other possible sources of error, I conducted, simultaneously with my observations, a second series of temperature-determinations by means of thermometers inclosed in a wooden case placed near the objective of the telescope. A fan, driven by clockwork, exhausted the air from this case and produced a steady influx of external air through channels placed just opposite the bulbs of the thermometers. The thermometers were read through a plate glass window in one side of the case which completely protected them from radiation from the observer. I am far from maintaining that the second system of temperature-determinations is free from systematic error, but it appears that such errors, if present, must be nearly constant, since the chief sources of variable error have been effectually eliminated.

To determine the relation between the two systems of temperature-determination thus outlined, I have formed mean results of all the comparisons made between arbitrarily chosen limits of temperature, and have thus derived the numbers in the column $V—W$, ventilated—whirled thermometer, of the following table in which n denotes the number of comparisons and τ the corresponding mean temperature in degrees C.

Limits.		n	τ	V-W	O—C
+28	+20°	18	+21.°	+0.11	+0.04
20	15	29	17.5	— .08	— .09
15	10	37	12.5	— .10	— .03
10	+ 5	18	7.5	— .06	+ .08
+ 5	0	46	+ 2.5	— .19	+ .03
0	— 5	17	— 2.5	— .21	+ .08
— 5	—19	19	—12.5	—0.58	—0.11

The presence of a real systematic difference between V and W cannot well be doubted, and I have adopted as its expression

$$V—W = c\,(\tau—\theta)$$

$$c = +0^\circ.015 \ \pm 0^\circ.003 \qquad \theta = +17^\circ \ \pm 3^\circ$$

The numbers in the column O—C represent the comparison of this formula with the data from which it is constructed. This correction has *not* been employed in computing the refractions, but is taken into account in a manner to be subsequently explained. The division-corrections of all of the thermometers employed were determined by comparison with a standard thermometer, whose errors were determined, through the courtesy of the Chief Signal Officer, U.S.A., in the Signal Office at Washington.

Before proceeding to a discussion of results furnished by the star-observations, it will be well to consider briefly the measure of precision of the observations themselves. A cursory examination of the instrument and of the theory of the observations may easily produce an unfavorable impression, since the possible sources of error are conspicuous, and the means of avoiding or eliminating their effect by no means so obvious. An account of the precautions which have been taken against these sources of error would require much more space than can here be given to it, and I must content myself with indicating that constant errors in the observations will have no effect upon the resulting value of the aberration, and that a measure of the effect of errors, not constant, is furnished by the probable error of a single observation. The term single observation, as here employed, designates the value of the angular distance between two stars which is furnished by the measures of a single night. A single observation, as thus defined, usually requires from fifteen to thirty minutes of time, and is always made at the epoch when the stars composing a pair are at approximately equal zenith-distances.

From a discussion of the residuals furnished by 146 such observations, made upon five pairs of stars at zenith-distances ranging from 62° to 74°, I find that within these limits the probable error of a single observation is very approximately represented by the empirical formula

$$r_1 = \pm \left\{ 0''.22 + 0''.0075(z-60^\circ) \right\}$$

There is no residual, among the 146, so great as 1″.0. The degree of precision represented by this value of r will become apparent when it is considered that, among the numerous sources of accidental error, whose combined effect is here represented, are included errors in the temperature-determinations upon which the computed refractions depend. The probable error of the refraction arising from this source was found by **Gyldén** (*Obs. Poulc, Vol. V, pp.* (23).(24)) to be 0″.00152 for each second of refraction. The average value of the refraction affecting these observations is $R = 195''$, from which it appears that this source alone should contribute to r_1, a component exceeding the total value of r_1 furnished by the observations. Since a considerable part of the value of r_1 must be due to other sources than the refraction, it appears that there is a gross discordance between the measures of uncertainty attributed to the computed refractions by the Pulkowa and Madison observations, and the cause of this difference is not far to seek. The refraction is a function of the angle between the ray of light in question and the normal to the lowest stratum of homogeneous air. In the use of the tables this normal is assumed to coincide with the vertical, an assumption which must frequently be in error to a very appreciable degree. This tilting of the strata will have no effect upon the apparent distance between two stars but may seriously affect measured zenith-distances, and it was from a discussion of the latter that **Gyldén**'s value above given was derived. A considerable part of the uncertainty of the refraction in zenith-distance must therefore be attributed to the tilting of the strata of air rather than to errors in the data from which the refraction is computed, a circumstance which tends to establish the superiority of those methods of investigating the refraction which are not affected by a displacement of the strata.

There are at present available for discussion about 800 observations of 33 pairs of stars, about 200 of which were made by Mr. A. S. **Flint** and the remainder by myself. A comparison of these results furnishes, as the systematic difference between the observers, the value

$$C.-F. = -0''.02 \pm 0''.08$$

indicating no sensible difference. There is however a marked difference in the precision of the observations, and I have therefore not included Mr. **Flint**'s observations in this provisional discussion. I have also admitted a considerable number of my own observations, in which the aberration-coefficients are either very small or so nearly constant that they were considered unsuitable for my present purpose. In the discussion of the remaining data I have sought first to eliminate the effect of the error in the temperature-determinations above noted, and such other errors depending upon the temperature as may affect the observations. For this purpose I have compared observations of the same pair of stars made at approximately the same season of the year, but at widely different temperatures. The form of observation equation adopted for this purpose is

$$A_\tau = \Delta_0 + \frac{d}{g}\cdot \tau g' + \tau a$$

where τ denotes the observed temperature, d the measured micrometer distance between the images in the telescope, g the value of a revolution of the screw, g' the temperature coefficient of the screw, and a a constant to be determined in connection with g'. The unit in which τ is expressed is one division of the thermometer of the scale, (0°.5 *C.*). By comparing the mean results of observations made at high and low temperatures each pair of stars may be made to furnish an equation of the type

$$A_{\tau'} - A_{\tau''} = \frac{d}{g}\cdot\frac{\tau'-\tau''}{100}x + \frac{\tau'-\tau''}{30}y$$

where

$$x = 100g' \qquad \text{and } y = 30a$$

The weights of these several equations were determined from the expression

$$p = \frac{n'\,n''}{n'+n''}$$

where n' and n'' represent the number of nights upon which the given pair of stars was observed at the higher and lower temperatures τ' and τ''.

The amount of available data is greatly diminished by the condition that the observations to be compared shall not be separated by any considerable interval of time, but it has seemed to me necessary to impose this condition on account of possible error in the adopted aberration constant (**Struve**) and possible differences in the amount of the refraction at different seasons. The following groups of normal equations from the Spring and Autumn observing are derived respectively from six pairs of stars, having an average weight of 2.0, and fifteen pairs with an average weight of 2.2.

Spring Normals.	Autumn Normals.
$25.69x + 3.08y = +0.90$	$213.18x + 9.17y = +9.28$
$3.08x + 10.66y = +2.01$	$9.17x + 30.04y = +2.72$
$x + 0.120y = +0.035$	$x + 0.043y = +0.043$
$y = +0.184$	$y = +0.078$

The difference in the values of the unknowns derived from the Spring and Autumn observing is not greater than the uncertainty of the determinations themselves, and I have

therefore included all of the data in a single discussion, furnishing the following results:

$$x = +0''.037 \quad wt. = 235 \qquad g' = +0''.00037 \ \pm 0''.00016$$
$$y = +0.105 \quad wt. = 40 \qquad a = +0.0035 \ \pm 0.0013$$

The quantity a is at least partially due to the error in the temperature-determinations above considered, and it also includes the effect of whatever error may be contained in the coefficients of expansion of air adopted in the construction of the factor γ of the refraction tables. If r_0 represent the refraction at the normal temperature of the tables, 9°.3 *C.*, m the adopted coefficient of expansion of air, and I_1 the concluded distance between a pair of stars measured at the temperature τ_1, we may readily derive the relation

$$-\frac{I_2 - I_1}{\tau_2 - \tau_1} = 2a = r_0\,(dm + cm)$$

where dm represents the correction to the adopted value of m. Introducing the values above derived for a and c and putting $r_0 = 195''$, a mean value, we obtain

$$dm = -0.000019$$

i.e., the quantity a is completely accounted for by the known errors of the temperature determinations together with a small correction to the coefficient of expansion of air adopted in the construction of the Pulkowa Refraction Tables. This value $m = 0.003689$ was derived from a discussion of observations made with the Pulkowa vertical circle (*Obs. Poulc. Vol. V.*), and it is worthy of note that the correction dm here determined furnished a value

$$m = 0.003670 \pm 16$$

in exact agreement with Regnault's classical determination. While this agreement is in part accidental, I am nevertheless inclined to regard it as furnishing a confirmation of the corrections derived for the indications of the whirled thermometer, since without the application of these corrections a value of m equal to 0.003725 would have been obtained, and there can be no doubt that this result is very considerably in error.

I have applied to all of the measured distances corrections based upon the values of g' and a thus obtained, and these corrected values of Δ are the data available for a determination of the aberration. To derive a value of this constant, I have united into a single mean the results of all of those observations of a pair of stars in which the constant of aberration appears multiplied by a positive coefficient, and have formed a similar mean corresponding to negative coefficients. The average value of the mean coefficient is 1.5. If it were permissible to assume that observations made at different seasons of the year were directly comparable a value of the constant of aberration, which I shall represent by k, might be derived from the observations of each pair of stars through the relation

$$k\,(f_a - f_s) = \Delta_a - \Delta_s$$

where f denotes the aberration-coefficient and the subscripts relate to Spring and Autumn observations. But since there are both theoretical and empirical reasons for supposing that the amount of the refraction may vary with the seasons in a manner not entirely represented by the tables, I have included in the determination of the aberration an investigation of this possible source of error.

Whatever may be the errors of the tabular refractions, r_0, we may assume without sensible error that the true refraction, r, is represented by an expression of the form

$$r = r_0\,(1+y)\,(1+x)$$

where y is a constant and x is a function of the time having a period of a year. Since we are now concerned only with variations of the refraction, the constant $r_0\,(1+y)$ may be replaced by r_1, which does not differ sensibly from r_0, and we may put

$$x = s\sin(\tau \cdot 360^\circ + S) = s\sin(\vartheta + S)$$

where τ is the fraction of a year corresponding to any date. Denoting by Δk a correction to the assumed value of k derived on the assumption that $x = 0$, by z the correction to be obtained when x is properly taken into account and putting

$$r_0\, s\cos S = \alpha \qquad r_0\, s\sin S = \beta$$

the resulting form of observation equation becomes

$$z + \frac{\sin\vartheta_a - \sin\vartheta_s}{f_a - f_s}\,\alpha + \frac{\cos\vartheta_a - \cos\vartheta_s}{f_a - f_s}\,\beta = \Delta k$$

From 465 observations of Δ, I have derived 25 equations of this type and have assigned them weights by the formula

$$p = \frac{n'\,n''}{n' + n''} \cdot \frac{f_a - f_s}{3}$$

where n' and n'' are the number of observations corresponding to f_a and f_s. The weighted equations I have combined into the following normals by a process of summation in such a manner as to obtain maximum coefficients for the several unknown quantities:

$$\begin{aligned} 88.8\,z + 4.13\,\alpha - 7.86\,\beta &= +3''.37 \\ 14.6\,z + 39.57\,\alpha - 30.29\,\beta &= -2.59 \\ 9.4\,z + 32.61\,\alpha - 32.63\,\beta &= -2.83 \end{aligned}$$

It is obvious that these equations will not furnish a good determination of α and β, and I therefore introduce in place of them new unknowns determined by the relations

$$2m = \alpha + \beta \qquad 2n = \alpha - \beta$$

and obtain after dividing by the coefficient of z

$$\begin{aligned} z - 0.042\,m + 0.135\,n &= +0''.0379 \\ z + 0.636\,m + 4.785\,n &= -0.1775 \\ z - 0.002\,m + 6.940\,n &= -0.3010 \end{aligned}$$

These are sufficient to determine n and z and show that m

will have but a trifling effect upon them. Solving for all three quantities I obtain

$z = +0''.0457.$ $m = +0''.0252.$ $n = -0''.0500.$

If values of s and S are derived from m and n we shall find as the effect upon the refraction

$$r = r_0 + 0''.08 \sin(\tau \, . \, 360 + 108^\circ)$$

i.e., the refraction is a maximum near the time of the winter solstice and a minimum near the summer solstice. Although the constants in this expression are not well determined, the equations strongly indicate a real variation in the amount of the refraction, whose amplitude and epoch they are unable to determine because by far the larger part of the observations were made in the Spring and Autumn months, and can give but little information in regard to the refraction at other seasons.

In order to obtain a measure of the precision with which z is determined I have computed the values of the several terms in α and β and have applied them as corrections to the Δks, thus obtaining the following values of z:

Stars		Weight	z
			″
β *Piscium*.	19 *Monoc*.	1.6	+0.10
γ *Ceti*.	*l* *Leonis*	2.3	+ .05
32 *Eridani*.	95 *Leonis*	1.5	— .09
10 *Tauri*.	ν *Leonis*	1.5	+ .18
μ *Tauri*.	ν *Virginis*	1.5	+ .08
π^5 *Orionis*.	δ *Virginis*	2.2	+ .18
ο *Orionis*.	DM. +2°.2661	1.2	— .11
θ *Canis Maj*.	ζ *Bootis*	4.2	+ .08
ε *Tauri*.	ζ *Corvi*	5.8	.00
119 *Tauri*.	α *Virginis*	6.0	+ .11
19 *Monoc*..	110 *Virginis*	3.6	+ .02
γ *Gemin*..	109 *Virginis*	5.7	+ .06
μ *Virginis*.	ζ *Pegasi*	4.2	— .03
37 *Librae*.	70 *Pegasi*	3.4	— .18
β *Librae*.	γ *Piscium*	1.5	— .01
110 *Virginis*.	β *Piscium*	3.0	+ .30
3 *Serpentis*.	ς *Aquarii*	6.5	+ .05
δ *Ophiuchi*.	ι *Ceti*	5.7	+ .25
B.A.C. 5903.	μ *Piscium*	4.9	— .04
Ll. 32200.	DM.—0°.258	1.4	+ .21
ι *Coronae*.	A^2 *Aquarii*	2.3	+ .11
511 *Scuti*.	ζ *Ceti*	5.5	+ .05
η *Aquilae*.	α *Ceti*	4.3	— .19
ν *Aquilae*.	*f* *Tauri*	6.1	+ .08
ι *Aquilae*.	10 *Tauri*	2.9	— .08

The value of k with which the aberrations were computed was $20''.4451 \sec \varsigma = 20''.418$, whence the provisional value of the constant from the present series of observations is

$$k = 20''.491 \pm 0''.017$$

the probable error being derived from the individual values of z given above.

The correction to the absolute amount of the tabular refractions, represented above by the factor $1+\eta$, may be investigated by comparing the measured distance between any pair of stars with the computed distance furnished by their right-ascensions and declinations, and by taking the mean result from a considerable number of pairs the errors in the star places will be nearly eliminated. I have not however made this discussion, but have contented myself for the present with results derived from other and better data furnished by the observations. If three stars be supposed situated in the equator, each distant 120° from each of the others, the sum of the measured distances between these several pairs of stars will furnish the relation

$$I' + I'' + I''' = 3\,(120 + K)$$
$$+ d' + d'' + d''' + R' + R'' + R''' = 360^\circ$$

If the stars are not situated in the equator, the sum of the distances between them will differ from 360° by a quantity depending upon their declinations and if these declinations are small this correction may be determined with extreme precision from values of the declinations which are only fairly well known. The principle of the method is, in effect, that the refraction must be so determined that the measured circumference of the heavens shall equal 360°.

I have included in my observing programme six such triplets of stars, all of which are included within the zone between $\delta = +4°$ and $\delta = -6°$. From modern catalogues of precision I have derived places of these stars, and have compared the distances between the stars which are furnished by these places with the corresponding measured distances, instead of projecting these latter upon the equator. It is apparent that the right-ascensions are perfectly eliminated by this process, and that errors in the declinations produce effects which involve $\sin \delta$ as a factor. The following table exhibits the measured and computed distances of the several pairs of stars together with the sum of the excesses of the computed over the observed distances for each triplet. The weights of these sums are derived from the formula

$$p^{-1} = n_1^{-1} + n_2^{-1} + n$$

where n is the number of observations of a given pair.

Stars	Computed Δ	Obs'd Δ	Σ C — O	p
	° ′ ″	″	″	
16 *Aquarii*	120 1 52.88	52.06		
ο *Orionis*	119 58 11.15	10.05	+2.15	2.6
DM. +2°.2661	119 51 29.59	29.36		
γ *Piscium*	119 55 22.21	19.92		
19 *Monocerotis*	120 3 51.35	51.66	+1.56	1.9
110 *Virginis*	119 59 1.17	1.89		
f *Piscium*	119 55 1.10	1.19		
23 *Hydrae*	119 54 12.69	11.13	+0.31	3.2
U *Ophiuchi*	120 9 23.13	21.59		
DM. —0°.258	119 55 17.87	17.40		
ι *Hydrae*	120 0 15.14	15.89	+0.02	2.6
Ll. 32200	120 1 58.82	57.62		
α *Ceti*	119 58 34.50	32.78		
ρ *Leonis*	119 59 2.47	1.29	+1.65	2.5
η *Aquilae*	119 59 13.57	11.72		
10 *Tauri*	120 0 51.57	51.45		
ν *Leonis*	119 51 35.93	35.45	+0.79	1.4
ι *Aquilae*	120 2 18.11	18.22		

The names of the stars are to be taken cyclically in pairs. Thus the distance in the first line of the table is that from 16 *Aquarii* to *o Orionis*, etc.

By a succession of accidents the measures of *α Ceti* – *ρ² Leonis* have been rendered quite uncertain; and, although the result from the triplet is in fairly good agreement with that from the other stars, I prefer to reject it until additional observations of this pair are secured. The several quantities $\Sigma\,(C.-O.)$ represent the amounts by which the circumference of the heavens exceeds the sum of the measured distances and each triplet indicates that the tabular refraction should be increased. The weighted mean of the several results is $+1''.48$ and since the mean value of the refraction for all of the pairs of stars is $R = 197''.6$ we have in the customary notation

$$3\,R_0\left(1+\frac{\Delta\alpha}{\alpha}\right) = 3\,R_0 + 1''.18$$

$$\log\left(1+\frac{\Delta\alpha}{\alpha}\right) = 0.00087$$

i.e. the refractions of the Pulkowa tables will represent this series of observations if 87 units be added to the logarithm of μ. It is to be noted however that in the computation of the refractions with which the observations were reduced the tabular value of $\log\mu$ was diminished by 61 units to take into account the difference in the force of gravity at Pulkowa and Madison,

$$\log\frac{1-0.00259\cos 2\varphi}{1-0.00259\cos 2\varphi_0} = 9.99936$$

and if this correction is omitted, as is usually done, the remaining part of the correction, 23 units of the fifth decimal place, is a quantity of the same order of magnitude with the probable errors of the determination of μ. The probable error of $\log\mu$ from the Pulkowa determination is ± 28 units, and from the above results ± 17 units.

I know no theoretical reason for omitting the gravity-correction, and if it is applied the computed refractions will require a further correction of very sensible magnitude. This correction may be equally well represented as due to error in the tables or to a constant error in the temperature determinations. The indications of the whirled thermometer have been shown to require a correction depending upon the temperature, and, if to this term a constant be added making the complete correction

$$\Delta\tau = -0^{\circ}.56 + 0^{\circ}.015\,(\tau-17^{\circ}) = +0\ .015\,(\tau-54^{\circ}),$$

the observations will be perfectly represented by the Pulkowa refractions. If BESSEL's refraction is employed the corresponding expression will be

$$\Delta\tau = +0^{\circ}.015\,(\tau+4^{\circ})$$

but the γ factor of BESSEL's table requires considerable correction.

Further progress toward a knowledge of the absolute amount of the refraction can be made only through an investigation of the constant errors affecting the temperature determinations.

I must here acknowledge my indebtedness to the Trustees of the Watson Fund of the National Academy of Sciences for pecuniary aid extended to this investigation.

Washburn Observatory, 1892 March.

MINIMA OF *Y CYGNI* AND *λ TAURI* OBSERVED IN 1891.

BY PAUL S. YENDELL.

Y Cygni.

My observations of *Y Cygni*, obtained during the season of 1891, afford thirteen minima. With the exception of one, all were deduced from the single light-curves; in the case of the minimum occurring on August 20, the actual minimum was not observed, the star being hidden by clouds; enough observations, however, were made during the increase and decrease, to yield a fair determination of the minimum, by the application of a mean light-curve.

The residuals, O—C, in the subjoined table, are those obtained by comparison with CHANDLER's latest catalogue-elements; those in the column *s* are the departures from the mean, indicated by the use of the sine-term proposed by me in Vol. X of this Journal, p. 132, and are given for the purpose of comparison with the residuals derived from the actually observed times.

E	Observed Time						⊙	O—C	*s*	*w*
				h	m			m	m	
1145	1891	Aug.	20	14	44.1	Local M.T.	+1.36	— 30.1	+103	3
1163		Sept.	16	13	15	”	+4.6	— 50.3	+ 94.6	4
1165			19	12	56	”	+1.5	— 61.0	+ 92.0	5
1169			25	12	46	”	+1.2	— 63.5	+ 89.3	4
1183		Oct	16	10	33	”	+2.8	—160.1	+ 78.8	4
1189			25	10	28	”	+2.1	—149.6	+ 73.5	3
1191			28	10	32	”	+1.8	—140.5	+ 71.7	5
1195		Nov.	3	10	16	”	+1.5	—146.0	+ 68.2	5
1197			6	10	20	”	+1.1	—137.0	+ 66.3	5
1205			18	10	32.5	”	±0.0	—104.5	+ 58.7	2
1211			27	9	21.0	”	—0.9	—160.2	+ 52.8	4
1213			30	9	14.0	”	—1.2	—162.1	+ 50.7	4
1215		Dec.	3	9	10.0	”	—1.5	—161.0	+ 48.7	4

Two minima observed by DUNÉR, and published by him in the *Astronomische Nachrichten*, No. 3051, show, by comparison with the same elements, a mean residual of $+138^m.9$ for the mean Epoch 1135; from this Epoch until 1183, a rapid decrease of period occurs, the mean period for this interval being $1^d\ 11^h\ 51^m\ 4^s$, showing a mean shortening of $6^m\ 14^s$. My own observations from Epoch 1163 to 1183 alone, indicate a mean period of $1^d\ 11^h\ 51^m\ 48^s$, the average shortening indicated being $5^m\ 30^s$.

From Epoch 1183 to 1215, the mean period is $1^d\ 11^h\ 57^m\ 16^s.3$, being only $1^s.7$ shorter than that of the elements used in the comparisons.

A glance at the columns O—C and *s* at once disposes of the elements embodying the latter term, and after many attempts, I fail to find any formula which will account for the observed departures from the mean indicated by CHANDLER's Elements.

λ *Tauri.*

Four fairly determined minima of λ *Tauri* were obtained by me from the series observable in the evening during October 1891, and the observed times are given below; the January 1892 group was entirely shut out by cloudy weather, to my great regret. The observed minima are

	h	m		w	
1891 Oct. 17,	10	28	local M.T.	4	Full moon abt $1^h\ 40^m$ p star
21,	10	22	"	1	Moon bright
25,	10	10	"	1	
29,	8	59	"	3	

Dorchester, Mass., 1892 *March* 19.

S PERSEI.

BY A. ŠAFAŘIK.

This star has been under my scrutiny almost without interruption since 1879; and in No. 3011 of the *Astronomische Nachrichten* I have given provisional dates of the only five maxima, which occurred from 1880 to 1889, the last of them 1889 Dec. 4. The longest interval was 952 days, the shortest 814 days, and the mean 881 days.

From these data no maximum was to be expected before 1892 Feb. 25. On the 17th of April, 1891, the star was $= 9^M.2$ and slowly brightening. After that day, owing to extensive repairs in my house, I could not look at the star sooner than July 6, when to my astonishment I found it nearly in full light $= 7^M.7$, and in that brightness, with very small fluctuations, the star continues to shine until to-day (1892 March 12), *i.e.* for full eight months. I regret that I could not observe the transition from $9^M.2$ to $7^M.7$, and see whether it was gradual or sudden. It must have been accomplished in less than two and a half months, whilst in 1882 and 1889 the same transition occupied fully four months. To show the remarkable constancy of the light of the star in its present phase I subjoin the monthly means of my observations since July, 1891:

1891	July	8 days	38.1 Steps	
	August	3	38.0	
	September	8	37.2	
	October	6	35.4 $= 8^M.0$	Scale of DM.
	November	6	38.1	
	December	3	38.5	
1892	January	1	38.5	
	February	4	38.9	
	March	3	38.9 $= 7^M.7$	

It is a new illustration to the empirical rule: the longer the period, the less regular the variation of light, a rule, which distinctly points to a specific difference between long-period and short-period variables. It would be of much interest to have the spectrum of the star accurately examined. In March 1887, two months before maximum, Mr. ESPIN found a banded spectrum of third type.

Prague, 1892 *March* 14.

OBSERVATIONS OF COMET *a* 1892 (*SWIFT*),

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 9.6-INCH EQUATORIAL

BY PROF. E. FRISBY.

(Communicated by the Superintendent.)

1892 Washington M.T.		✳	No. Comp.	☉ — ✳ Δα	☉ — ✳ Δδ	☉'s apparent α	☉'s apparent δ	log pΔ for α	log pΔ for δ
d	h m s			m s	′ ″	h m s	° ′ ″		
Mar. 28	16 28 50.9	1	19 , 1	+2 23.49	−0 34.1	20 36 22.33	−10 27 4.4	n9.581	0.789
	16 28 50.9	2	19 , 1	+2 21.30	−0 20.1	20 36 22.39	−10 27 5.0	n9.581	0.789
	16 28 50.9	3	19 , 1	+1 15.54	+7 14.1	20 36 22.88	−10 27 4.4	n9.581	0.789
	16 28 50.9	4	19 , 1	+1 32.34	+9 12.7	20 36 22.82	−10 26 59.6	n9.581	0.789
Mar. 29	16 5 22.7	5	10 , 2	+1 53.63	+1 51.1	20 40 18.76	−9 24 33.8	n9.606	0.779
	16 5 22.7	6	10 , 2	+1 38.23	−2 26.8	20 40 18.92	−9 24 34.1	n9.606	0.779

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	′ ″	
1	20 33 59.18	−0.63	−10 26 16.7	−0 10.3	Lamont 3334
2	20 34 1.72	−0.63	−10 26 31.6	− 10.3	Lamont 3334
3	20 34 38.01	−0.63	−10 34 35.0	− 10.2	Schjellerup 8200
4	20 34 51.11	−0.63	−10 36 2.1	− 10.2	Weisse's Bessel, XX. 836
5	20 38 25.76	−0.63	− 9 26 11.1	− 10.5	Schjellerup 8252
6	20 38 41.32	−0.63	− 9 24 57.1	−0 10.5	Weisse's Bessel, XX. 941

A NEW NEBULA,

BY E. E. BARNARD.

In observing DENNING's comet on March 21, I discovered a very small indefinite nebula in the field with it and s.pr. This nebula is about 12^M. It is about $\frac{1}{2}'$ in diameter, and has a very small and very stellar nucleus of the 12th magnitude. It was observed with the comet, using the same comparison star. It is not in DREYER's N.G.C.

$$\text{Neb.} - * \quad \Delta\alpha = +3^m\,25^s.77 \quad (6\text{ obs.})$$
$$\Delta\delta = +2'\,3''.4 \quad (5\text{ obs.})$$

The resulting place of the nebula is

$$1892.0 \quad \alpha = 23^h\,0^m\,39^s.92$$
$$\delta = +59°\,39'\,2''.4$$

NEW ASTEROIDS.

Two more small planets have been photographically discovered by Dr. WOLF, at Heidelberg:

12^M, 1892 Mar. 26.1111 Gr. M.T. $\alpha = 12^h\,13^m\,59^s.1$, $\delta = +1°\,37'\,0''$. Daily motion, -48^s in α, and 14′ northward

13^M, 1892 Mar. 28.416 Gr. M.T. $\alpha = 11^h\,22^m\,41^s$, $\delta = +6°\,9'$ Daily motion, -52^s in α, and 1′ northward

The asteroid no. 310 (CHARLOIS, 1891 May 16), has received the name *Margarita*.

COMETS OF THE YEAR 1891.

The dates are in Greenwich Mean Time, and the Elements only approximate.

Designation	Perihelion	☊	ω	i	q	φ	Discoverer	Date	Synonym	
		° ′		° ′		° ′				
I	April 27.52	193 56	178 48	120 31	0.3975		Barnard	March 29	*a*	
II	Sept. 3.16	206 22	172 49	25 15	1.5921	33 51	Spitaler	May 1	*b*	Periodic of Wolf
III	Oct. 17.98	331 41	183 57	12 55	0.3105	57 50	Barnard	Aug. 2	*c*	Encke's
IV	Nov. 12.91	217 39	268 33	77 13	0.9769		Barnard	Oct. 3	*e*	
V	Nov. 17.31	296 31	106 13	5 23	1.0866	40 45	Barnard	Sept. 27	*d*	Periodic: Tempel-Swift

CORRIGENDA IN VOL. XI.

Page 5, line 17, name of Comet, *for* 1891V *put* 1889V
" 96, col. 1, line 12, " 1826 " 1828
" 125, " 2, " 17, " p. 44 " p. 114
" 136, " 1, lines 9, 15, " 30 869 " 29 869
Page 140, col. 2, line 18, *for* 0″.384 *put* (0″.0384)
" 144, line 11, " *b* 1892 " *a* 1892
" 156, col. 2, line 21, " *u* " *y*

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ON THE PARALLAX OF δ *HERCULIS* FROM OBSERVATIONS MADE BY DEMBOWSKI.

BY F. P. LEAVENWORTH.

DEMBOWSKI'S *Double-Star Observations*, Vol. II, contain sixty-eight observations of this double star, spread over a period of sixteen years. Having made a series of measures on the same star, and obtained a parallax of $+0''.05$, I thought it worth while to reduce his observations for parallax.

All the observations were used and given equal weight. They were corrected for proper motion, differential refraction, precession, and aberration. The assumed value of the proper motion, $\Delta\alpha = -0''.080$; $\Delta\delta = +0''.166$, was first changed to position-angle and distance.

On account of the great period of time over which the series extends, they were divided into two groups and solved separately. The first group was reduced to the year 1866.0, and the second to 1875.0. The observations with the corrections are given in the following table.

FIRST GROUP.

Date	Local Sid. Time h m	p	Proper Motion	Prec. and Refr.	s	Proper Motion	Aberr. and Refr.	1866.0 p	1866.0 s
1862.735	19 3	179.8	+0.58	−0.02	20.40	−0.546	+0.005	180.36	19.859
62.746	19 10	179.2	0.58	0.02	20.60	0.542	0.005	179.76	20.063
62.769	19 0	179.2	0.57	0.02	20.64	0.538	0.005	179.75	20.107
62.784	19 19	179.4	0.57	0.02	20.50	0.535	0.005	179.95	19.970
63.226	15 27	178.9	0.49	0.01	20.61	0.462	0.007	179.38	20.155
63.294	18 13	179.9	0.48	0.02	20.44	0.449	0.007	180.36	19.998
63.450	18 22	179.9	0.45	0.02	20.45	0.424	0.006	180.33	20.034
63.511	15 10	179.1	0.44	0.01	20.44	0.415	0.005	179.53	20.030
63.705	18 20	179.2	0.41	−0.02	20.32	0.383	0.005	179.59	19.942
65.297	16 3	179.6	0.13	0.00	20.38	0.116	0.007	179.73	20.271
65.338	19 5	179.9	0.12	−0.01	20.16	0.109	0.007	180.01	20.058
65.420	15 2	179.5	0.10	0.00	19.94	0.097	0.006	179.60	19.849
65.434	15 15	179.6	0.09	0.00	20.24	0.095	0.006	179.69	20.151
65.483	18 34	179.9	0.09	−0.01	20.27	0.087	0.006	179.98	20.189
65.533	15 31	179.6	0.09	0.00	20.16	0.078	0.005	179.69	20.087
65.612	18 22	179.1	0.07	0.00	20.19	0.064	0.005	179.17	20.121
65.732	18 25	179.8	+0.05	0.00	19.90	−0.045	0.005	179.85	19.860
66.431	15 17	179.8	−0.08	+0.01	20.09	+0.071	0.006	179.73	20.167
66.489	18 23	180.0	0.09	0.00	20.03	0.081	0.006	179.91	20.117
66.538	15 50	180.3	0.09	0.00	20.13	0.090	0.005	180.21	20.225
66.628	18 18	180.3	0.11	0.00	19.85	0.105	0.005	180.19	19.960
67.409	15 20	180.0	0.26	+0.01	19.88	0.234	0.006	179.75	20.120
67.513	15 10	180.1	0.28	0.01	19.82	0.251	0.005	180.13	20.076
67.576	18 25	180.1	0.29	0.01	19.80	0.262	0.005	180.12	20.067
68.335	18 46	180.9	0.43	0.01	19.61	0.388	0.007	180.48	20.005
68.164	15 12	180.4	0.45	0.02	19.87	0.408	0.006	179.97	20.284
68.527	15 22	179.8	0.46	0.02	19.68	0.420	0.005	179.36	20.105
68.653	18 49	180.7	0.49	0.01	19.54	0.440	0.005	180.22	19.985
69.178	15 44	180.9	0.64	0.03	19.45	0.577	0.006	180.29	20.033
69.519	15 32	180.2	0.65	0.02	19.47	0.584	0.005	179.57	20.059
69.551	18 17	180.6	0.65	0.02	19.63	0.590	0.005	179.97	20.225
69.637	18 20	180.6	0.68	0.02	19.33	0.605	0.005	179.94	19.940
70.253	15 52	181.2	0.79	0.03	19.43	0.705	0.007	180.44	20.142
70.437	15 7	181.1	0.83	0.03	19.45	0.736	0.006	180.30	20.192
70.508	18 54	181.1	0.84	0.02	19.22	0.747	0.005	180.28	19.972
1870.617	18 17	180.7	−0.86	+0.03	19.40	+0.766	+0.005	179.87	20.171

SECOND GROUP.

Date	Local Sid. Time	*p*	Proper Motion	Prec. and Refr.	*s*	Proper Motion	Aberr. and Refr.	1875.0 *p*	1875.0 *s*
	h m	°	°	°	″	″	″	°	″
1871.275	15 28	181.8	+0.75	−0.02	19.23	−0.613	+0.007	182.53	18.624
71.491	14 18	181.8	0.70	0.01	19.15	0.577	0.005	182.49	18.578
71.535	18 21	181.6	0.70	0.02	19.11	0.570	0.005	182.28	18.545
71.675	18 41	180.9	0.68	0.02	19.00	0.546	0.005	181.56	18.459
72.281	15 38	182.0	0.55	0.01	19.15	0.446	0.007	182.54	18.711
72.489	15 25	180.9	0.51	0.01	19.26	0.413	0.006	181.40	18.853
72.560	18 38	181.5	0.50	0.02	18.86	0.401	0.005	181.99	18.464
72.667	18 27	181.1	0.49	−0.01	19.06	0.383	0.005	181.58	18.682
73.229	14 58	182.4	0.35	0.00	18.85	0.290	0.007	182.75	18.567
73.489	15 22	180.7	0.31	0.00	18.78	0.248	0.006	181.01	18.538
73.636	18 26	181.4	0.28	−0.01	18.84	0.225	0.005	181.67	18.620
73.667	18 46	182.0	0.27	−0.01	18.81	0.219	0.005	182.26	18.596
74.497	15 21	181.6	0.10	0.00	18.67	0.082	0.005	181.70	18.593
74.516	15 15	181.3	0.10	0.00	18.63	0.081	0.005	181.40	18.554
74.634	18 55	181.7	0.06	0.00	18.72	0.061	0.005	181.76	18.664
74.678	19 5	181.8	+0.06	0.00	18.89	−0.055	0.005	181.86	18.840
75.441	18 58	181.9	−0.09	0.00	18.55	+0.071	0.006	181.81	18.627
75.444	14 33	181.5	0.09	+0.01	18.39	0.071	0.006	181.42	18.467
75.509	15 45	181.5	0.10	+0.01	18.51	0.083	0.005	181.41	18.598
75.671	18 53	182.5	0.12	0.00	18.60	0.109	0.005	182.38	18.714
76.241	15 23	181.7	0.26	+0.01	18.26	0.205	0.007	181.45	18.472
76.493	15 38	182.0	0.31	0.02	18.18	0.245	0.005	181.71	18.430
76.613	18 57	182.1	0.33	0.01	18.49	0.264	0.005	181.78	18.759
76.679	18 50	182.2	0.35	0.01	18.43	0.275	0.005	181.86	18.710
77.257	15 30	182.6	0.48	0.02	18.15	0.368	0.007	182.14	18.525
77.433	15 17	182.2	0.52	0.02	18.21	0.397	0.006	181.70	18.613
77.643	19 6	182.5	0.56	0.02	18.16	0.432	0.005	181.96	18.597
77.715	19 25	182.1	0.58	0.02	18.45	0.448	0.005	181.54	18.903
78.274	15 37	182.4	0.70	0.03	18.12	0.535	0.007	181.73	18.662
78.468	15 2	182.9	0.74	0.03	18.03	0.566	0.006	182.19	18.602
78.602	19 23	183.3	0.77	0.02	18.22	0.588	0.005	182.55	18.813
1878.709	18 47	182.2	−0.79	+0.02	18.06	+0.606	+0.005	181.44	18.671

The equations of condition were put in the form

$$x + by + cII - n = 0$$

where x is the error of the assumed value of the position-angle or distance; by the effect of the error of the assumed proper motion; cII the effect of parallax; and n the measured angle or distance, minus the assumed. The position-angle and distance were assumed to be

	°	″
1866.0	179.93	20.071
1875.0	181.87	18.627

FIRST GROUP.

	ANGLE		DISTANCE	
No.	Equation	Residual	Equation	Residual
	″	″	″	″
1	$x - 3.265\,y - 0.970\,II - 0.154 = 0$	−0.218	$x - 3.265\,y - 0.108\,II + 0.212 = 0$	+0.134
2	3.254 − 0.951 + 0.061	−0.003	3.254 − 0.158 + 0.008	−0.075
3	3.231 − 0.901 + 0.065	+0.002	3.231 − 0.256 − 0.036	−0.133
4	3.216 − 0.851 − 0.007	−0.067	3.216 − 0.326 + 0.101	−0.005
5	2.774 + 0.964 + 0.197	+0.186	2.774 + 0.112 − 0.084	−0.131
6	2.706 + 0.787 − 0.154	−0.170	2.706 + 0.411 + 0.073	+0.063
7	2.550 − 0.051 − 0.143	−0.176	2.550 + 0.757 + 0.037	+0.072
8	2.490 − 0.410 + 0.143	+0.101	2.490 + 0.717 + 0.011	+0.071
9	2.295 − 0.999 + 0.121	+0.067	2.295 + 0.032 + 0.129	+0.072
10	0.703 + 0.769 + 0.070	+0.079	0.703 + 0.432 − 0.200	−0.202
11	0.662 + 0.586 − 0.028	−0.021	0.662 + 0.574 + 0.013	+0.029
12	0.580 + 0.123 + 0.116	+0.110	0.580 + 0.741 + 0.222	+0.259
13	0.566 + 0.036 + 0.081	+0.076	0.566 + 0.752 − 0.080	−0.042
14	0.517 − 0.264 − 0.018	−0.032	0.517 + 0.741 − 0.118	−0.080
15	0.467 − 0.541 + 0.081	+0.063	0.467 + 0.669 − 0.116	−0.087
16	$x - 0.388\,y - 0.873\,II + 0.267 = 0$	+0.239	$x - 0.388\,y + 0.425\,II - 0.050 = 0$	−0.052

No.	Angle Equation			Residual	Distance Equation			Residual
				″				
17	$x - 0.268y$	$- 0.971H$	$+ 0.028 = 0$	—0.001	$x - 0.268y$	$- 0.108H$	$+ 0.211 = 0$	+0.141
18	+ 0.131	+ 0.054	+ 0.070	+0.071	+ 0.431	+ 0.758	— 0.096	—0.056
19	0.489	— 0.295	+ 0.070	+0.066	0.489	+ 0.773	— 0.046	—0.002
20	0.538	— 0.568	— 0.098	—0.108	0.538	+ 0.656	— 0.151	—0.124
21	0.628	— 0.919	— 0.091	—0.108	0.628	+ 0.360	+ 0.111	+0.103
22	1.109	+ 0.188	+ 0.062	+0.081	1.109	+ 0.729	— 0.049	—0.007
23	1.513	— 0.437	— 0.069	—0.064	1.513	+ 0.705	+ 0.015	+0.054
24	1.576	— 0.746	— 0.066	—0.066	1.576	+ 0.536	+ 0.001	+0.021
25	2.335	+ 0.590	— 0.189	—0.149	2.335	+ 0.071	+ 0.066	+0.026
26	2.164	— 0.161	— 0.011	+0.009	2.164	+ 0.753	— 0.213	—0.166
27	2.527	— 0.523	+ 0.196	+0.211	2.527	+ 0.671	— 0.034	+0.004
28	2.653	— 0.973	— 0.100	—0.093	2.653	+ 0.243	+ 0.086	+0.069
29	3.478	— 0.244	— 0.123	—0.089	3.478	+ 0.746	+ 0.038	+0.087
30	3.519	— 0.479	+ 0.123	+0.151	3.519	+ 0.690	+ 0.012	+0.054
31	3.551	— 0.658	— 0.014	+0.010	3.554	+ 0.606	— 0.154	—0.123
32	3.637	— 0.943	— 0.003	+0.017	3.637	+ 0.313	+ 0.131	—0.126
33	4.253	+ 0.910	— 0.173	—0.102	4.253	+ 0.261	— 0.071	—0.080
34	4.437	+ 0.010	— 0.126	—0.075	4.437	+ 0.753	— 0.121	—0.069
35	4.508	— 0.117	— 0.119	—0.077	4.508	+ 0.707	+ 0.099	+0.146
36	$x + 4.617y$	$- 0.166H$	$+ 0.020 = 0$	+0.062	$x + 4.617y$	$+ 0.391H$	$- 0.100 = 0$	—0.092

SECOND GROUP.

No.	Angle Equation			Residual	Distance Equation			Residual
				″				
1	$x - 3.725y$	$+ 0.845H$	$- 0.229 = 0$	—0.138	$x - 3.725y$	$+ 0.358H$	$+ 0.003 = 0$	—0.019
2	3.506	— 0.338	— 0.205	—0.171	3.506	+ 0.727	+ 0.019	—0.029
3	3.165	— 0.564	— 0.138	—0.115	3.165	+ 0.653	+ 0.082	+0.017
4	3.325	— 0.998	+ 0.104	+0.104	3.325	+ 0.111	+ 0.168	+0.185
5	2.719	+ 0.817	— 0.224	—0.112	2.719	+ 0.392	— 0.081	—0.103
6	2.511	— 0.321	+ 0.157	+0.181	2.511	+ 0.730	— 0.226	—0.296
7	2.440	— 0.658	— 0.010	—0.032	2.140	+ 0.604	+ 0.163	+0.113
8	2.333	— 0.991	+ 0.097	+0.085	2.333	+ 0.165	— 0.055	—0.034
9	1.771	+ 0.955	— 0.292	—0.213	1.771	+ 0.168	+ 0.060	+0.085
10	1.511	— 0.299	+ 0.281	+0.300	1.511	+ 0.730	+ 0.089	+0.026
11	1.361	— 0.949	+ 0.066	+0.049	1.361	+ 0.296	+ 0.007	+0.011
12	1.333	— 0.991	— 0.129	—0.118	1.333	+ 0.163	+ 0.034	+0.060
13	0.503	— 0.367	+ 0.056	+0.061	0.503	+ 0.718	+ 0.034	—0.018
14	0.481	— 0.175	+ 0.151	+0.151	0.484	+ 0.686	+ 0.073	+0.026
15	0.366	— 0.360	+ 0.036	+0.039	0.366	+ 0.306	— 0.037	—0.023
16	— 0.322	— 0.094	+ 0.003	+0.018	— 0.322	+ 0.112	— 0.213	0.168
17	+ 0.111	— 0.017	+ 0.020	+0.030	+ 0.111	+ 0.754	0.000	—0.049
18	0.441	— 0.017	+ 0.116	+0.156	0.441	+ 0.754	+ 0.160	+0.111
19	0.509	— 0.441	+ 0.149	+0.139	0.509	+ 0.696	+ 0.029	—0.012
20	0.671	— 0.998	— 0.159	—0.197	0.671	+ 0.136	— 0.087	—0.038
21	1.211	+ 0.923	+ 0.135	+0.183	1.211	+ 0.245	+ 0.155	+0.192
22	1.193	— 0.350	+ 0.052	+0.037	1.193	+ 0.720	+ 0.197	+0.158
23	1.613	— 0.902	+ 0.029	—0.011	1.613	+ 0.372	— 0.132	+0.112
24	1.679	— 1.007	+ 0.003	—0.045	1.679	+ 0.084	— 0.083	—0.015
25	2.257	+ 0.895	— 0.086	—0.049	2.257	+ 0.508	+ 0.102	+0.158
26	2.133	— 0.009	+ 0.051	+0.046	2.133	+ 0.755	+ 0.011	0.016
27	2.613	— 0.964	— 0.029	0.085	2.643	+ 0.255	+ 0.030	+0.077
28	2.715	— 0.950	+ 0.105	+0.019	2.715	— 0.223	— 0.276	—0.153
29	3.271	+ 0.831	+ 0.011	+0.069	3.271	+ 0.387	— 0.035	—0.005
30	3.468	— 0.653	— 0.101	—0.151	3.168	+ 0.753	+ 0.025	—0.021
31	3.608	— 0.831	— 0.215	—0.275	3.608	+ 0.123	— 0.186	—0.158
32	$x + 3.709y$	$- 0.998H$	$+ 0.136 = 0$	+0.068	$x + 3.709y$	$0.015H$	$0.014 \quad 0$	+0.050

From these equations of condition the following normal equations were derived:

ANGLE. — First Group.

$$\begin{aligned}
+36.000\,x + 18.634\,y - 10.597\,\Pi + 0''.088 &= 0\\
+18.634\,x + 239.876\,y - 3.395\,\Pi - 2.773 &= 0\\
-10.597\,x - 3.395\,y + 15.587\,\Pi - 0.346 &= 0
\end{aligned}$$

ANGLE. — Second Group.

$$\begin{aligned}
+32.000\,x + 0.550\,y - 10.345\,\Pi - 0''.017 &= 0\\
+0.550\,x + 169.457\,y - 5.083\,\Pi + 1.855 &= 0\\
-10.345\,x - 5.083\,y + 17.159\,\Pi - 0.699 &= 0
\end{aligned}$$

DISTANCE. — First Group.

$$\begin{aligned}
+36.000\,x + 18.634\,y + 16.118\,\Pi - 0''.113 &= 0\\
+18.634\,x + 239.876\,y + 21.524\,\Pi - 2.350 &= 0\\
+16.118\,x + 21.524\,y + 11.195\,\Pi - 0.591 &= 0
\end{aligned}$$

DISTANCE. — Second Group.

$$\begin{aligned}
+32.000\,x + 0.550\,y + 13.321\,\Pi + 0''.013 &= 0\\
+0.550\,x + 169.457\,y - 3.176\,\Pi - 1.881 &= 0\\
+13.321\,x - 3.176\,y + 7.986\,\Pi + 0.420 &= 0
\end{aligned}$$

The solutions of these equations give

	p First Group		p Second Group		s First Group		s Second Group	
	''	''	''	''	''	''	''	''
x	−0.002	±0.015	+0.016	±0.019	−0.055	±0.021	+0.066	±0.024
y	+0.012	±0.005	−0.040	±0.007	+0.003	±0.005	+0.008	±0.006
Π	+0.021	±0.022	+0.048	±0.025	+0.127	±0.040	−0.159	±0.049
r		±0.077		±0.094		±0.072		±0.075
weight. Π		12.119		13.673		3.223		2.373
$[nn.3]$		0.4295		0.5636		0.3739		0.3572
$[vv]$		0.1291		0.5637		0.3732		0.3576

The disagreement of the values of the parallax derived from the measures of distance was to be expected, on account of the small values of the weights in the normal equations. Giving each result its respective weight, the mean value of the parallax is

$$\Pi = +0''.030 \pm 0''.015$$

agreeing very closely with my own result

$$\Pi = +0''.050 \pm 0''.014$$

The corrected position-angle, distance, and proper motion, are

	1866.0	1875.0
p	179.92	181.92
s	20''.016	18''.693
μ_α	−0''.092	−0''.070
μ_δ	+0''.163	+0''.158

OBSERVATIONS OF THE NEW STAR IN *AURIGA*,

By J. G. HAGEN, S.J.

Observations of the new star were begun at Georgetown College Observatory on February 9, and were continued until the star disappeared in the 5-inch equatorial. Though the star was visible to the naked eye for a month, opera glasses were used from the beginning because of the strong moonlight then prevailing.

It will be noticed that in the two means on the right side the last two stars of 9.5 mag (DM.) have been discarded, for well known reasons.

If no difference were made between the observations by opera glass and those by telescope, the value of one step would come out $0^{M}.050$. In no. 239 of this Journal, page 177, my step-value for the same telescope was shown to be $0^{M}.046$, from nearly 300 observations in the years 1889 and 1890.

The last column, headed M, of Table I, was computed from the following Table II, and gives the reduced magnitudes as they result from the observations. In order to make these magnitudes (M) as nearly as possible coincident with those of the DM., the arithmetical means of the steps and the DM. magnitudes were taken as corresponding quantities, in other words, step 20 was equated to $5^{M}.97$ for the opera glass observations, and step 70 to $8^{M}.54$ for the telescopic observations.

TABLE I. COMPARISON-STARS.

OPERA GLASS				TELESCOPE			
Comp. Star	Stps	DM	M	Comp. Stars	Stps	DM.	M
		M				M	
DM. +33 1000	0.0	5.1	5.1	DM. +29 923	59.7	7.8	7.8
32 922	6.0	5.5	5.3	29 921	66.7	8.5	8.3
32 1024	6.9	4.8	5.4	30 912	68.2	8.5	8.4
33 1013	11.1	5.9	5.5	30 913	75.2	8.7	8.9
30 963	18.0	6.0	5.9	30 911	85.4	9.4	9.5
30 898	21.7	6.2	6.2	30 920	91.7	9.5	9.9
29 947	29.1	6.2	6.1	30 924	95.7	9.5	10.1
29 899	36.2	7.0	6.6				
29 911	53.7	7.5	7.1				

1 step = 0.045 mag.

$$\text{Mean of steps} = \frac{186.0}{9} = 20.7$$

$$\text{Mean of mag.} = \frac{54.2}{9} = 6.0$$

1 step = 0.062 mag.

$$\text{Mean of steps} = \frac{355.2}{5} = 71.0$$

$$\text{Mean of mag.} = \frac{42.9}{5} = 8.6$$

From these starting points Table II has been computed by the corresponding values of one step.

TABLE II. CORRESPONDING STEPS AND MAGNITUDES.

Opera Glass		Telescope	
Steps	Mag.	Steps	Mag.
0.0	5.1	60.0	7.8
5.0	5.3	65.0	8.2
10.0	5.5	70.0	8.5
15.0	5.8	75.0	8.9
20.0	6.0	80.0	9.2
25.0	6.2	85.0	9.5
30.0	6.4	90.0	9.8
35.0	6.6	95.0	10.1
40.0	6.9	100.0	10.4
45.0	7.1		
50.0	7.3		
55.0	7.5		

The following table gives the results of the observations. The latter were reduced in the two ways described by ARGELANDER (*Schumacher's Jahrbuch*, 1844, p. 232) and SCHÖNFELD'S (*Wiener Sitzungsber.*, Bd. 42, p. 154), the arithmetical mean being taken as the final results. These are headed by "Steps." The last column headed "Mag." was computed by means of Table II.

A few numbers have been distinguished in parenthesis as less certain, since they rest on only one comparison-star, while all the others rest on two, the one slightly brighter, the other slightly fainter than the *Nova*. Some of these cases are owing to the light of the Moon, and two of them to the comparison-star DM. +29° (953+954), the brightness of which was estimated differently on different nights, and which was consequently rejected. The combined magnitude of the two components ($7^M.0$ and $7^M.5$) would be $6^M.5$.

TABLE III. RESULTS OF OBSERVATIONS.

1892	Gr. T. h m	Steps	Mag.
Feb. 9	15 0	8.6	5.4
10	12 15	8.5	5.4
11	13 45	5.5	5.3
12	14 50	10.8	5.5
13	14 24	13.1	5.7
14	15 40	3.0	5.2
15	11 59	21.8	6.1
	13 27	19.2	6.0
	14 11	19.6	6.0
	16 1	23.5	6.1
Feb. 16	11 19	(22)	(6.1)
	12 23	(21)	(6.2)
17	11 51	(10)	5.5
	11 55	13.6	5.7
	12 21	14.1	5.8
	13 7	14.1	5.8
	14 21	14.1	5.8
	15 26	14.1	5.8
22	11 41	22.1	6.1
	13 12	26.0	6.2
Feb. 22	15 0	25.6	6.2
23	11 35	21.8	6.1
	13 2	22.5	6.1
	17 21	22.3	6.1
Mar. 3	11 46	15.3	5.8
	13 25	15.9	5.8
	18 8	19.9	6.0
5	12 45	21.8	6.1
	14 57	22.5	6.1
6	11 5	26.8	6.3
9	13 0	(10)	(6.9
Mar. 10	13 50	(44)	(7.1)
11	15 0	(58)	(7.7)
14	13 14	62.2	7.9
16	13 13	66.8	8.3
19	12 42	80.8	9.2
	14 2	78.8	9.2
	14 53	79.8	9.2
21	12 15	90.6	9.8
	15 52	89.5	9.8
28		(116)	>(11)

March 5. Strong moonlight: obs. difficult.
6. Strong moonlight: sky hazy.
9. Moon: sky hazy.
10. Moon.
11. Strong moonlight.
13. *Nova* invisible in opera glass.

As far as these observations go, they show great fluctuations of light in the middle of February, while towards the end of the same month the star was withdrawn from observation by cloudy weather.

From March 3, a sudden and regular decline of brightness is shown, until the star disappeared in the telescope.

Among the great fluctuations during February two maxima are evidenced, viz.: on February 14 and 17.

Changes within a few hours are indicated on Feb. 15, 17 and 22.

In what follows the results are given of two other members of our observatory, Fathers J. ALGUE and J. T. HEDRICK, which confirm the conclusions arrived at before. These observations were made with opera-glasses and reduced to the DM. scale of magnitudes.

1892	Gr. T. h m	A M	Hk. M
Feb. 9	14		5.3
11	15		5.4
14	16		5.2
15	12 30	6.0	
	15		5.9
17	12 6	5.4	5.5
	12 50	5.7	
	13 25	5.3	
	14 15	5.6	
	15 0	5.4	
	16 0	4.9	
22	12 0	5.8	
	12 35		6.1
	15 32	6.2	6.1
Feb. 23	12 10	5.8	6.1
	15 7	5.7	6.1
Mar. 3	12 20	5.8	6.0
	15 7	5.7	6.0
5	12 15	5.9	
	13 58		6.1
	15 0	5.6	
6	11 10	6.0	6.3
	11 59	6.1	6.4
	16 20		6.3
9	13 30	6.6	
10	12 30	7.2	
	13 30	7.0	
11	13 0	7.2	

Georgetown College, 1892 *April* 1.

PHOTOMETRIC OBSERVATIONS OF THE NEW STAR IN *AURIGA*.

BY HENRY M. PARKHURST.

I have observed the new star on every evening when it was visible, from Feb. 6 until its disappearance. In the following table, the evenings when the clouds were specially troublesome, are indicated by colons. The scale is that of the Harvard Photometry. For standards I employed 21 stars, which had been compared with the circumpolar standards by 57 Meridian Photometer observations, requiring 228 equalizations. I also employed 20 additional stars, down to

the limit of visibility with 9 inches aperture. These observations required 112 extinctions; making a total of 670, in addition to the observations of the *Nova*. My observations being taken in pairs, my record shows 335 observations of the comparison-stars. The *Nova* was observed on 26 evenings, 52 observations, as indicated by the subscript figures following the magnitudes. Usually the series for each evening included 8 comparison-stars and two observations of the *Nova*, making 20 extinctions. The 13 surplus observations arose from occasional double series of observations, which more than counterbalanced the occasional shorter series. The comparison-stars were selected as nearly as practicable from stars nearly equal to the *Nova* in brightness, and equally above and below. The fluctuations up to March 6, especially for the first fortnight, seem to be actual phenomena. So also the regular rapid descent until the disappearance, excepting the break on March 20, and apparently another at the close. There is a group of 6 stars, from 11^M.1 to 14^M, very near and surrounding the *Nova*; and possibly there may be a 13^M.5 star in the position of the *Nova*. The indeterminate nature of the comparisons largely *inter sese*, leaves the accuracy of the scale for future investigation. The hour of observation was not noted; but it was probably invariably about 12^h Greenwich Mean Time, until the last four dates, when it was an hour later.

1892	M	1892	M	1892	M
Feb. 6:	5.13_2	Feb. 22	5.81_2	Mar. 16	8.64_2
9	4.78_2	27	6.05_2	19	9.98_2
10:	5.19	Mar. 3	5.73_2	20	10.12_2
11	5.38	6	5.81_2	21	10.64_2
13	4.86_2	7	6.05_2	24	11.81_2
15	5.53_2	9	6.65_2	25:	12.13_2
16	5.60_2	13	7.60_2	28	13.19_2
17	5.63_2	14	7.82_2	29	13.28_2
18	5.13_2	15	8.24		

Brooklyn, N. Y., 1892 March 31.

ON THE WASHINGTON PRIME-VERTICAL OBSERVATIONS,

By S. C. CHANDLER.

By courtesy of the Superintendent, and Prof. S. J. Brown, of the Naval Observatory, I have been afforded access to the observations in the prime-vertical, in 1882–84. It is evident on the most cursory examination that there is no such startling difference as has been supposed, between them and the corresponding series of 1845–50. I give below the values of the latitude, referred to Boss's system, derived from stars employed by Prof. Comstock on p. 118,—excepting B.A.C. 6365, whose place is very uncertain, and of which there is but one observation in the earlier series:

Star	Obs. 1847	Obs. 1883	Latitude 1847	Latitude 1883	Diff.	Wt.
			″	″	″	
μ *Andromedae*	17	31	38.19	37.88	—0.31	3
π *Herculis*	7	28	37.80	37.87	+0.07	2
ε *Herculis*	6	24	38.50	38.22	—0.28	2
θ *Herculis*	3	19	37.54	39.04	+1.50	1
α *Lyrae*	217	120	37.76	38.06	+0.30	10
40 *Cygni*	7	18	37.58	38.41	+0.86	2
Gr.1450	2	31	37.57	38.37	+0.80	1
10 *Leonis min.*	3	10	37.63	37.97	+0.34	1
31 *Leonis min.*	5	23	37.89	38.23	+0.34	1
17H. *Can. Ven.*	3	11	37.32	38.48	+1.16	1
10 *Lacertae*	8	38	37.89	38.20	+0.31	2

The first six stars are in Boss's list. The places of the others I have supplied, using the principal authorities, with his systematic corrections and weights. They are as follows:

	°	′	″		
Gr.1450	+38	26	35.73	—0.166	$(t-1875)$
10 *Leonis min.*	36	57	4.31	—0.025	„
31 *Leonis min.*	37	20	48.88	—0.106	„
17H. *Canum Ven.*	37	49	24.18	—0.013	„
10 *Lacertae*	38	24	0.31	—0.016	„

The mean values of the latitude are:

	1847	1883	Diff.	Wt.
	″	″	″	
First six stars	37.873	38.117	+0.244	20
Last five stars	37.698	38.242	+0.544	6
Mean of all	37.833	38.146	+0.313	26

We thus have, instead of a difference of 1″.5 according to Prof. Comstock, one of only 0″.3, a quantity which is entirely within the range of the uncertainty of the results and the effect of the periodical variation. The discordance between us arises, first, from an inadvertence of Prof. Comstock, in assuming, apparently, 38″.80 as the value of the latitude used in the reduction of the 1883 series, instead of 38″.34 corresponding to the prime-vertical piers: secondly, from difference in the proper motions. For the stars in question there is an average difference of about —0″.015 (Boss–Auwers) annually. This happens to be somewhat larger than the average amount by which I think Auwers's system is drifting annually to the north of Boss's.

The above affords still another illustration of the fact that "it is premature to speculate upon the secular variation until the laws of the periodical variation are more fully understood." It also appears that the presumed secular variation of American latitudes must now rest upon the Madison results alone. It further shows how futile is the expectation that the proposed reoccupation of Asian stations will contribute information, as to the secular variation, which cannot be far more economically obtained at home. The general result of my examination of this question is that, if any secular change exists, it must be less than a hundredth of a second annually. Differential methods therefore will, for a very long while to come, be powerless

to reveal it, for we have no system of proper motions sufficiently beyond suspicion to enable us to cope with so elusive a quantity. All such systems must necessarily have been twisted by the effect of the periodical variation upon the declinations of the older catalogues. It is therefore not true, as Prof. Comstock maintains, that the effect of errors in the proper motions "may be almost indefinitely diminished by increasing the number of stars employed." On the contrary, I think we must hold to a view diametrically opposite to that which he has advanced, with regard to the relative value of differential and absolute methods in detecting secular changes of latitude, and instead of discarding the evidence of the latter on this point, must base our hopes in this regard upon observations above and below the pole, relying on differential methods only for the periodical variation.

Cambridge, 1892 *April* 9.

COMET *a* 1892 (*SWIFT*).

By Rev. G. M. SEARLE.

Director of the Observatory of the Catholic University, Washington, D.C.

The ephemeris of this comet, published in number 260 of this Journal, having soon proved inaccurate, as was to be expected from the middle-place residuals, I thought it worth while, as a fairly good interval of time had elapsed, to compute a new orbit without any assumption as to eccentricity. The materials used for this, the best attainable at the time, were a place for Mar. 11 formed from the mean of Prof. Frisby's observation of that date and mine, assigning double weight to the former, another similarly formed for Mar. 21, and an observation which I secured on Mar. 28.

The orbit strictly representing these places proved to be hyperbolic, and is as follows:

$$T = \text{April } 6.6177 \text{ Gr. M.T.}$$

$$\left.\begin{aligned} \omega &= 24^\circ\ 28'\ 40'' \\ \Omega &= 241\ \ \ 5\ \ 17 \\ i &= 38\ \ 47\ \ \ 2 \end{aligned}\right\}\ 1892.0$$

$$\log q = 0.012382$$
$$\log e = 0.005195$$

The discordances of the middle place are zero, the computation being made only to the nearest second of arc, with six-place logarithms.

The coordinate equations are:

$$\begin{aligned} x &= [9.923093]\ r \sin(v + 349^\circ\ 10'\ \ 7'') \\ y &= [9.999771]\ r \sin(v + 257\ \ 56\ \ 18) \\ z &= [9.739828]\ r \sin(v + 345\ \ \ 6\ \ 41) \end{aligned}$$

The following parabolic orbit, however, represents the middle place with a $\Delta\alpha$ of +15″ and $\Delta\delta$ of +7″:

$$T = \text{April } 6.8325 \text{ Gr. M.T.}$$

$$\left.\begin{aligned} \omega &= 24^\circ\ 13'\ 55'' \\ \Omega &= 240\ \ 59\ \ 13 \\ i &= 38\ \ 49\ \ \ 2 \end{aligned}\right\}\ 1892.0$$

$$\log q = 0.011581$$

The coordinate equations for this are:

$$\begin{aligned} x &= [9.922380]\ r \sin(v + 349^\circ\ 17'\ 52'') \\ y &= [9.999787]\ r \sin(v + 258\ \ \ 7\ \ 22) \\ z &= [9.739661]\ r \sin(v + 345\ \ 23\ \ 37) \end{aligned}$$

These latter give the following ephemeris for Greenwich midnight:

		α			δ		log Δ	Br.
		h	m	s	°	′		
Apr.	10	21	21	19	+ 2	42.8	0.0367	1.36
	11		27	55	3	42.7		
	12		31	29	4	12.0	.0407	
	13		35	1	5	10.6		
	14		38	31	6	38.5	.0452	1.29
	15		41	59	7	35.7		
	16		45	26	8	32.2	.0500	
	17		48	51	9	27.8		
	18		52	14	10	22.6	.0552	1.21
	19		55	36	11	16.7		
	20	21	58	56	12	10.1	.0606	
	21	22	2	14	13	2.6		
	22		5	31	13	54.3	.0662	1.12
	23		8	46	14	45.1		
	24		12	0	15	35.0	.0720	
	25		15	12	16	24.1		
	26		18	23	17	12.3	.0780	1.02
	27		21	32	17	59.7		
	28		24	40	18	46.2	.0840	
	29		27	46	19	31.9		
	30	22	30	50	+20	16.6	0.0901	0.93

The corrections to this ephemeris, to obtain the corresponding hyperbolic places, are only —5ˢ and 1′.0 for April 10, and —19ˢ and —3′.4 for April 30. By an observation which I obtained here this morning (April 10), for which the comparison-stars have been only approximately located, the correction to this ephemeris would seem as yet to be quite small; so that no deviation from a parabola is apparent.

The situation of the orbit seems to be such that unusually large changes (especially for such a rapidly-moving comet) can be made in the elements, without materially affecting the places from which they are obtained.

The nucleus of the comet is very sharp, the coma considerably more extended on the side away from the tail; there seem to be small jets in that direction, particularly on the northern side. The tail shows as two distinct streams, the dark space in the middle being as broad as the two streams together.

The comet appeared to the naked eye, in strong moonlight, about as bright as α *Equulei*.

FILAR-MICROMETER OBSERVATIONS OF COMET *a* 1892 (*SWIFT*),

MADE WITH THE 16-INCH EQUATORIAL OF THE GOODSELL OBSERVATORY.

BY H. C. WILSON, ASSISTANT.
Communicated by Prof. WM. W. PAYNE, Director.

1892 Northfield M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			m s	′ ″	h m s	° ′ ″		
Mar. 7 17 18 5	1	3 , 1	−6 3.72	+1 7.6	19 3 15.76	−30 31 17.8	*n*9.416	0.905
13 17 31 10	2	4 , 4	+4 22.48	−7 26.0	19 34 49.38	−25 26 32.6	*n*9.455	0.888
15 17 37 12	3	10 , 2	+0 21.71	+1 1.4	19 41 2.95	−23 34 45.1	*n*9.435	0.886
20 17 29 0	4	10 , 10	−0 11.65	−1 12.3	20 3 16.50	−18 40 59.7	*n*9.448	0.870

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	19 9 20.36	−0.88	−30 38 50.6	−4.8	½(Yarnall (F) 8366 + Stone 10448)
2	19 30 27.67	−0.77	−25 19 0.0	−6.6	½(Lamont + Washington Tr. Z.)
3	19 40 41.99	−0.75	−23 38 12.4	−7.1	Oe.Arg. S. 15675
4	20 3 28.84	−0.69	−18 39 39.0	−8.1	Oe.Arg. S. 15916

The corrections for refraction have been applied. The transits were noted by eye and ear March 7 and 13; on the other dates the chronograph was used.

The comet had a well-defined nucleus, and on March 20 the beginning of a "fan" was noted on the sunward side.

THE SPECTRUM OF COMET *a* 1892 (*SWIFT*).

BY W. W. CAMPBELL.

This morning I obtained an observation of this bright comet with the spectroscope of the 36-inch equatorial. The spectrum is at present of the usual type. The spectrum of the nucleus is apparently continuous and visible from about *C* to *G*. It was made quite broad by the long telescope, and I observed that it was more sharply defined on the east edge than on the west [the slit was parallel to the equator]. Later it was seen that the sharp edge and the diffuse edge corresponded to the sides of the nucleus from and towards the tail.

The three well known yellow, green and blue bands were present, their intensities being approximately in the ratio 1 : 6 : 2. Their lower edges were quite sharply defined. When the slit was narrowed to 0.001 inches, the bright line on the lower edge of the green band became exceedingly sharp, and could be bisected by the micrometer-thread with extreme accuracy. There was apparently no condensation at the point where it crossed the continuous spectrum, except what would be expected from the superposition of the two, thus showing that the bright line is characteristic of the coma rather than of the nucleus.

The wave-lengths of the less refrangible edges of the bands were obtained by comparison with nine lines in the iron and magnesium spark-spectra. A 60°-prism was used, there being insufficient time before dawn to change to a higher dispersive power. However, the distances to be measured were short, especially for the middle band, and the settings could be made very accurately; and I give the results to four and five places, as below:

$\lambda = 5630$	$\lambda = 5170.4$	$\lambda = 4722$
31	.4	24
28	.5	22
$\lambda = 5630$	$\lambda = 5170.4$	$\lambda = 4723$

These wave-lengths are not corrected for relative motion of the earth and comet.

Mt. Hamilton, 1892 *April* 6.

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DECLINATIONS OF 36 STARS FROM OBSERVATIONS WITH PRIME-VERTICAL TRANSIT OF THE UNITED STATES NAVAL OBSERVATORY.

Communicated by PROF. STIMSON J. BROWN, U.S.Navy, with the permission of the Superintendent.

In the fall of 1882 a series of observations was begun on the Prime-Vertical Transit by Lieutenants INGERSOLL and BOWMAN, U. S. Navy, for the determination of the constant of aberration. Lieut. INGERSOLL was succeeded in June, 1883, by Lieut. HIERO TAYLOR. Observations were continued until July, 1884; from April, however, only *α Lyrae* was observed for parallax. The observations were partially reduced by Lieut. TAYLOR, and a preliminary discussion of the correction to the constant of aberration made from the materials afforded by twelve stars. There have been so many requests for the observed declinations of these stars, for use in discussing probable secular and periodical changes in latitude, that they are published, by courtesy of the Journal, in advance of the official publication in the Washington Observations.

The observing list comprises 36 stars between the declinations of 36° 57′ and 38° 10′. With the exception of *α Lyrae* the observations were made at the periods of maximum effect of aberration, so far as this could be accomplished with the limited aperture of the telescope.

The instrument is fully described in the Washington Observations for 1862. Having been out of use for fifteen years, it required general cleaning and repairing, which was thoroughly done by Mr. W. F. GARDNER, instrument-maker of the Observatory. The instrument was adjusted in azimuth and collimation at the beginning of the observations in 1882, and remained satisfactorily constant, the only changes necessary being as follows:

Dec. 19, 1882	adjusted	level,	N.end 2″.0	high.
July 18, 1883	"	"	S.end 2″.0	"
Oct. 5, 1883	"	"	S.end 1″.7	"
Feb. 21, 1884	"	"	N.end 1″.8	"

A new spirit-level, procured from WURDEMANN, proved to be a good one. The value of the level-division was tested by several series of observations with three different level-triers, one belonging to the Coast and Geodetic Survey, one to Prof. WM. HARKNESS, and one procured from STACKPOLE for the Prime-Vertical Work. There were made independent determinations of the value of one revolution of the screw of the one procured for the Observatory, and the value of the level resulting from its use was adopted, as follows:

$$1 \text{ div.} = \left\{ 1.0102 \pm 0.0059 \right\}'' + \left\{ 0.0011\,(t - 1) \right\}''.$$

With a few exceptions the times were noted from Howard clock, No. 627, attached to the south wall of the observing room, and recorded on a Bond electric chronograph. The rate and error of the clock were derived from chronographic comparisons with the observing clock of the East Transit-instrument. Comparisons were made at the time of observations for clock-correction of the latter, and also at the time of observations on the prime-vertical Transit. The rate of the Howard clock proved to be unexpectedly uniform. In but few cases did the correction to the elapsed time between the two verticals amount to more than 0ˢ.2.

The method of observing was essentially the same as that adopted by STRUVE in his later work with the Pulkowa P.V. Transit, the level remaining undisturbed on the axis during the reversals of the instrument. The telescope was set at the proper position of the star at its transit over the east vertical, and four readings of the level were made immediately preceding the transit. Transit of the star over the desired number of wires being observed, the telescope was reversed on its axis, and transits over the same wires observed in the second position of the instrument. Immediately after, four readings of the level were again made. In the same manner the star was observed over the west vertical.

The formulas employed in the reductions of the observations are the same as those employed by OTTO STRUVE in his Prime-Vertical work at Pulkowa. As these have been fully given by Prof. A. HALL, in a recent number of the Journal, and the effects of the instrumental constants fully discussed there, further reference to them is unnecessary. The adopted latitude of the piers was 38° 53′ 38″.31. The reductions to mean place are computed by the Besselian star-constants and numbers, the latter being taken for each observation from the tables of the American Ephemeris for

the time of the star's transit over the meridian. All the reductions to observed and mean place for the first twelve stars of the list were made and checked by Lieuts. **Bowman**, **Ingersoll** and **Taylor**. Of the remaining twenty-four, the reductions were made by Lieut. **Taylor**. The remaining reductions and the checking of Lieut. **Taylor's** work were done by myself, with the assistance of Mr. **Geo. A. Hill**.

In the accompanying tables are given the name of the star, with the assumed mean place for 1883.0, the mean date, the observer's initial, the number of wires observed, the computed and observed apparent place, and the general remarks made in the original observing books. No observations have been omitted, nor in any case have the records of the observers been changed.

p Andromedae.

$\alpha = 0^h\ 50^m\ 15^s.76.\quad \delta = 37°\ 51'\ 51''.96\quad \mu' = +0''.028$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1882 Dec 11.3	I	9	37 52 7.16	37 52 7.02	
11.3	I	9	7.33	6.33	
16.3	I	9	7.34	7.24	
28.3	B	7	7.31	6.71	
1883 July 16.7	I	9	51 55.83	51.86	Light fog, clouds
30.7	I	9	58.94	58.11	Fairly good image but steady
31.7	I	9	59.21	59.66	Fair image
Aug 2.7	I	9	59.71	59.59	Good image, steady
6.7	I	9	52 0.62	0.75	Very much diffused and very unsteady at intervals
7.7	I	9	0.82	0.17	Fair image, somewhat unsteady
12.6	I	9	1.99	2.17	Good
Oct 31.4	B	7	20.28	20.23	High wind, fair seeing star very steady, a little diffused
Nov 3.1	T	9	20.81	20.23	Bad, diffused and unsteady
5.1	B	9	21.19	21.55	Image good
12.4	B	7	22.08	22.15	Fair, image rather diffused
14.4	B	9	22.32	21.66	Poor
15.1	T	8	22.47	22.17	Diffused and unsteady
16.4	B	9	22.62	22.20	Fair
19.1	B	9	23.07	23.09	Good
27.1	T	8	23.67	23.68	Poor
28.3	B	8	23.75	24.17	Fair
30.3	B	8	23.94	24.75	Good
Dec 3.3	B	9	24.23	24.28	Diffused
5.3	B	11	24.35	23.40	Very steady
6.3	T	8	24.39	24.59	Good
10.3	B	9	24.46	24.41	Diffused
11.3	T	8	24.49	24.35	Diffused and unsteady
21.3	B	10	24.75	24.69	Lt. clouds, but fair seeing
28.3	B	9	24.59	24.74	Lt. clouds, but distinct and good image
29.3	T	10	24.59	24.72	Good, well defined and steady
1884 Jan 3.2	T	8	24.40	24.45	Good image
6.2	T	7	24.14	24.27	Very poor and unsteady
22.2	B	9	22.70	23.33	Thin clouds, very faint, but steady
26.2	T	9	37 52 22.33	37 52 22.59	Very faint, excellent image

1450 Groombridge.

$\alpha = 8^h\ 25^m\ 18^s.45\quad \mu = -0^s.015.\quad \delta = 38°\ 24'\ 58''.68\quad \mu' = -0''.208.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Feb 8.17	B	11	38 24 46.51	38 24 47.36	Fair, growing hazy
19.4	I	12	47.73	47.92	Good
23.4	B	11	48.37	49.59	
28.4	B	10	48.94	49.92	
Mar 1.4	I	10	49.03	49.61	
3.4	I	10	49.24	49.99	
7.4	B	10	49.81	50.21	
8.4	I	10	49.96	50.58	
13.4	I	10	38 24 50.50	38 24 51.21	

1450 Groombridge. — Contin.

$\alpha = 8^h\ 25^m\ 18^s.45\quad \mu = -0^s.015.\quad \delta = 38°\ 24'\ 58''.68\quad \mu' = -0''.208.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Mar 14.1	B	6	38 24 50.58	38 24 50.79	Good
20.4	I	10	51.21	51.79	
21.4	B	10	51.38	51.77	Not good, unsteady and not well defined
21.3	I	10	51.76	51.73	
Apr. 3.3	I	10	52.57	53.13	
Oct 31.7	T	9	33.45	34.31	Poor, diffused and unsteady, very faint
Nov 1.7	B	8	33.30	34.38	Faint light clouds
4.7	B	8	32.90	34.38	Poor
5.7	T	8	32.81	33.67	Very faint, light clouds
12.7	T	11	32.23	33.48	Bad image
14.7	T	9	31.98	33.18	Poor, moon, diffuse and unsteady
16.7	T	8	31.72	32.37	Diffuse and unsteady
18.7	B	6	31.53	32.83	Poor
19.7	T	6	31.47	32.12	Diffuse and unsteady
27.7	B	9	31.04	31.32	Bad image, haze
28.7	T	9	30.94	32.54	Not good seeing
29.7	B	9	30.85	31.88	Clouds, very faint at times, particularly after reversal
30.7	T	8	30.77	32.43	Faint, but fairly defined
1884 Mar 24.3	B	10	39.40	39.82	Fair
31.3	B	.	39.98	40.65	Clouds, but good image and steady
April 5.3	T	. .	40.37	41.08	
7.3	B	. .	38 24 40.60	38 24 41.12	Good

10 Leonis Minoris.

$\alpha = 9^h\ 27^m\ 03^s.21\quad \mu = -0^s.015.\quad \delta = 36°\ 54'\ 58''.46\quad \mu' = -0''.010.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 April 14.3	I	9	36 54 50.87	36 54 50.88	Clear and well defined
17.3	I	9	51.25	51.13	Steady and well defined
Dec 9.7	B	9	26.33	26.03	Good
10.7	T	9	26.22	26.59	Unsteady
28.6	T	8	25.13	25.01	Fair
1884 Jan. 9.6	T	9	25.12	25.37	Good
13.6	B	11	25.16	25.95	Fair seeing
17.6	B	10	25.46	25.30	Fair. Poor image and clouds after reversal
21.6	T	9	25.68	25.76	Poor, diffuse
April 7.3	B	8	36 54 34.98	36 54 35.40	Good. Image a little diffused

31 Leonis Minoris.

$\alpha = 10^h\ 21^m\ 06^s.92\quad \mu = -0^s.011.\quad \delta = 37°\ 18'\ 22''.73\quad \mu' = -0''.077.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 April 10.4	I	10	37 18 13.41	37 18 12.44	Good
17.4	I	9	14.35	13.93	Good
18.4	B	9	14.53	14.06	Good, moon bright
20.4	B	5	14.86	14.39	Bright moon, good
21.3	I	9	15.02	14.42	Good image
24.3	I	9	15.36	14.76	Fair
25.3	B	9	37 18 15.45	37 18 14.88	Good

31 Leonis Minoris. — Contin.

$\alpha = 10^h\ 21^m\ 06^s.92$ $\mu = -0^s.011.$ $\delta = 37°\ 18'\ 22''.73$ $\mu' = 0''.077.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 April 30.3	B	9	37 18 15.99	37 18 15.49	Steady, but faint through clouds
May 2.3	B	9	16.26	16.26	Steady. Seen through light clouds
3.3	B	9	16.40	16.77	
4.3	I	7	16.52	15.74	Faint, but steady
Dec 9.7	B	11	17 48.41	47.47	Image not good
27.7	B	9	46.43	46.15	High wind, fleecy clouds, image steady
28.7	T	8	46.33	46.58	Poor, diffuse and unsteady
1884 Jan. 2.6	T	9	46.10	46.38	Poor
9.6	T	5	45.85	45.79	Fair image seen through thin clouds
13.6	B	9	45.73	45.46	Fair, bright moon
17.6	B	10	45.88	46.08	Seen through thin clouds
20.6	B	9	46.00	45.55	Image diffuse at times
21.6	T	9	46.01	46.85	Poor
April 17.4	T	9	57.21	56.69	Fair image
18.4	B	9	57.35	56.93	Fair image
29.3	T	9	37 17 58.72	37 18 58.62	Good image

17 H) Can. Ven.

$\alpha = 13^h\ 29^m\ 34^s.28$ $\mu = +0^s.13.$ $\delta = 37°\ 46'\ 55''.62$ $\mu' = -0''.007$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 May 2.45	B	8	37 46 17.93	37 46 17.46	Good
16.4	B	9	51.08	50.37	Good
17.4	I	9	51.33	50.85	Good
19.4	I	9	51.84	51.81	Good
24.4	I	9	52.82	52.58	Good
25.4	B	9	52.98	52.94	Fair
31.4	I	9	54.16	54.09	Fair
June 1.4	B	8	54.38	54.64	Fair
4.4	B	7	54.93	53.45	Thin clouds, good
11.3	B	7	55.92	55.49	Light clouds
1884 Jan 13.7	B	7	21.21	21.19	Through clouds
21.7	T	8	20.32	20.80	Poor
Feb 15.7	T	9	19.13	20.13	Diffuse
26.7	B	6	37 46 19.64	37 46 19.64	Fair

π Herculis.

$\alpha = 17^h\ 10^m\ 58^s.33$ $\mu = -0^s.004.$ $\delta = 36°\ 56'\ 29''.59$ $\mu' = -0''.010.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 April 8.7	B	10	36 56 17.99	36 56 16.74	Good
June 27.45	B	9	38.53	38.62	Good. Light clouds
July 1.4	I	6	39.73	39.33	Fair
2.4	B	9	40.01	40.29	Good
3.4	I	9	40.28	40.02	
4.4	B	9	40.52	41.19	Good. Lt. clouds after reversal
10.4	I	9	41.88	42.07	
14.4	I	9	42.96	43.24	Steady
16.4	B	9	43.17	43.80	Good
17.4	I	9	43.69	43.86	Good
25.4	B	9	45.24	45.69	Lt. clouds, but seeing good
26.4	I	10	45.47	45.87	Good
30.4	B	8	46.33	46.61	Good seeing
31.4	T	8	46.49	46.91	Good seeing
Aug 6.3	T	9	36 56 47.34	36 56 47.74	Fair seeing

π Herculis. — Contin.

$\alpha = 17^h\ 10^m\ 58^s.33$ $\mu = -0^s.004.$ $\delta = 36°\ 56'\ 29''.59$ [illegible]

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Aug 7.3	T	9	36 56 47.51	36 56 47.74	[illegible]
22.3	T	9	49.39	50.17	[illegible]
Sept 1.3	T	9	50.05	50.47	
3.3	B	8	50.13	50.50	[illegible]
4.3	T	9	50.20	51.03	[illegible]
5.3	B	9	50.27	50.62	[illegible]
6.3	T	9	50.34	51.11	[illegible]
1884 Mar 30.7	B	11	14.87	14.83	Lt. clouds
April 6.7	B	8	15.59	15.73	
11.7	T	9	16.15	16.77	
17.6	B	7	17.55	18.21	[illegible]
18.6	T	9	17.70	17.96	[illegible]
29.6	B	10	36 56 20.17	36 56 20.16	[illegible]

i Herculis.

$\alpha = 17^h\ 13^m\ 37^s.9.$ $\delta = 37°\ 24'\ 52''.56$ $\mu' = +0''.046$

Date	Obsr	Thds	Computed δ	Observed δ
1883 June 27.45	. . . . .		37 25 1.70	37 25 1.55
July 1.4	. . . . .		2.93	3.33
3.4	. . . . .		3.47	3.18
4.4	. . . . .		3.72	3.75
10.4	. . . . .		5.09	5.84
13.4	. . . . .		5.92	5.79
14.4	. . . . .		6.49	6.34
16.4	. . . . .		6.70	6.85
17.4	. . . . .		6.93	7.54
18.4	. . . . .		7.13	7.13
21.4	. . . . .		7.68	8.34
25.4	. . . . .		8.50	8.42
26.4	. . . . .		8.74	9.20
Aug 4.4	. . . . .		9.93	10.53
7.3	. . . . .		10.84	11.48
22.3	. . . . .		12.74	13.10
1884 Mar 21.7	. . . . .		37.55	37.65
30.7	. . . . .		38.22	37.84
April 4.7	. . . . .		38.73	38.85
6.7	. . . . .		38.93	38.06
11.7	. . . . .		39.79	39.95
17.6	. . . . .		40.88	40.88
18.6	. . . . .		41.03	41.22
29.6	. . . . .		37 25 43.51	37 25 43.35

θ Herculis.

$\alpha = 17^h\ 52^m\ 14^s.41$ $\mu = -0^s.002$ $\delta = 37°\ 15'\ 59''.05$ [illegible]

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Apr 17.7	B	8	37 15 50.54	37 15 49.06	[illegible]
18.7	I	9	50.66	49.40	[illegible]
20.7	I	8	51.05	50.46	[illegible]
24.7	B	9	51.95	51.65	[illegible]
26.7	B	8	52.36	51.75	[illegible]
27.7	I	9	52.55	52.49	[illegible]
30.6	I	9	53.09	52.42	[illegible]
May 3.6	B	9	53.75	53.49	[illegible]
July 25.4	B	8	16 16.96	16.17	[illegible]
31.4	T	9	37 16 18.44	37 15 18.91	[illegible]

θ *Herculis.* — Contin.

α = 17h 52m 14s.41 μ = −0s.002 δ = 37° 15′ 59″.95 μ′ = +0″.016.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Aug 1.4	T	9	37 16 18.63	37 15 18.84	Star not well defined
6.4	T	9	19.50	19.12	Good, steady
7.4	T	9	19.70	19.70	Good, steady
21.3	T	6	21.83	22.16	Good
22.3	T	9	22.16	22.08	Good image
Sept 5.3	B	8	23.63	24.10	Faint, but steady
6.3	T	5	23.74		Good, faint
1884 Mar 27.7	B	6	15 19.35	18.12	Light clouds
30.7	B	10	19.66	18.14	
Apr 18.7	T	9	37 15 52.01	37 15 52.24	Not steady, diffuse

α *Lyrae.*

α = 18h 32m 58s.64 μ = +0s.017 δ = 38° 40′ 31″.55 μ′ = +0″.284.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1882 Nov 11.1	I	9	38 40 50.26	38 40 49.94	
15.1	B	10	50.01	50.00	
16.1	I	9	49.79	49.58	
22.1	B	13	48.43	48.40	
23.1	I	13	48.24	48.89	
24.1	B	13	48.05	48.00	
27.1	I	8	47.41	47.40	Bad seeing
Dec 2.1	B	13	46.01	45.63	
8.06	B	14	44.48	43.81	Not good, diffuse and unsteady
12.05	B	10	43.40	43.75	Indistinct, from clouds
16.04	I	13	42.41	42.01	
19.03	I	13	41.23	40.85	
29.0	B	13	38.21	37.88	
1883 Jan 1.99	B	13	36.96	37.47	Very unsteady
11.96	I	13	33.89	33.87	
14.95	I	13	32.96	32.78	Very unsteady
21.93	I	13	31.05	31.21	Passing clouds, but star well defined and steady
23.9	I	13	30.41	30.76	Clear and steady
31.9	I	13	28.26	28.31	
Feb 1.9	I	13	28.02	27.77	Hazy
26.8	I	13	22.81	22.53	
Mar 7.8	I	10	21.68	21.45	
21.8	I	10	20.93	20.98	Very bad on first, fair on second
27.8	B	10	21.08	20.73	Seeing not good
Apr 3.7	B	8	21.31	20.88	Fair, but light clouds
8.7	B	9	21.75	22.07	Very poor image, much diffused
17.7	B	7	22.79	22.60	3" aper ; rather diffuse
18.7	I	7	22.91	22.88	
20.7	I	7	23.22	22.58	Bad image
24.7	B	7	24.03	23.96	Bad image ; much diffuse
26.7	B	7	24.42	24.57	Used 1 1/4" aper. on first, full on second. Image fair
27.7	I	7	24.60	25.04	1 1/4" aper ; star app'd as small disc ; full aper ; much diff
30.7	I	7	25.08	24.91	Foggy
May 2.7	I	7	25.46	25.32	1 1/4" aper. first ; 3" second
3.7	B	7	25.67	25.05	" aper
6.6	B	7	26.44	27.70	Very bad image, 3" aper
9.6	I	7	27.23	27.61	Bad, unsteady, 1 1/4" aper.
17.6	B	7	29.09	28.71	Rather unsteady 1 1/4" aper
June 29.5	B	9	38 40 42.11	38 40 41.95	Diffuse, but seeing good

α *Lyrae.* — Contin.

α = 18h 32m 58s.64 μ = +0s.017. δ = 38° 40′ 31″.55 μ′ = +0″.284.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 July 2.5	B	10	38 40 43.15	38 40 42.90	A little unsteady, 1 1/4" aper.
3.5	I	13	43.46	43.02	
4.5	B	14	43.76	44.44	Good, 1 1/4" aper
10.5	I	8	45.39	45.34	Passing clouds
13.5	B	9	46.34	45.82	Seeing fair, 1 1/4" aper.
16.5	B	14	47.34	46.98	Good
17.5	I	10	47.60	47.57	Good
18.4	B	8	47.87	47.53	Image bad 1 1/4" aper
21.4	I	9	48.60	48.78	1 1/4" aper
23.4	B	9	49.09	48.95	Faint at times and unsteady
25.4	B	9	49.61	49.07	Image fair, but unsteady
26.4	I	9	49.93	50.44	Good, 1 1/4" aper
Sept 9.3	B	9	58.53	58.55	Light clouds, 1 1/4" aper ; very unsteady
15.3	T	9	58.94	58.69	1 1/4" aper
16.3	B	9	58.96	59.02	Full aper ; diffuse but unsteady
21.3	B	12	59.39	59.20	Seen through thin clouds
26.3	B	12	59.57	59.49	Full aper ; thin clouds
27.3	T	13	59.55	59.66	Light clouds ; star faint but steady
28.3	B	8	59.53	59.10	Image good
Oct 3.2	B	9	59.57	59.66	Clouds. Very faint at times
4.2	T	10	59.60	59.43	Poor, unsteady
10.2	B	10	59.41	60.04	Excellent
14.2	B	12	59.13	59.37	Fair, full aper on first, 1 1/4" on second
16.2	T	14	59.05	58.95	Full aper
21.2	B	12	58.44	58.77	
26.2	B	13	58.14	57.98	Clouds, but not thick
30.2	T	13	57.64	57.93	
31.2	B	10	57.55	57.94	Drifting clouds
Nov 3.2	B	10	57.20	57.58	Light clouds
5.1	T	12	56.87	56.87	
7.1	T	12	56.47	57.15	Very faint
12.1	T	15	55.52	55.13	Bad, diffuse and unsteady
14.1	T	14	55.21	55.61	Poor
15.1	B	10	55.05	55.51	Light, drifting clouds
16.1	T	13	54.88	55.71	Unsteady
17.1	B	14	54.68	55.14	
19.1	T	10	54.23	54.69	
21.1	B	7	52.95	52.69	Clouds. Faint at times
27.1	B	10	52.30	52.95	
28.1	T	11	52.09	52.74	
30.1	T	11	51.65	51.72	
Dec 5.1	T	11	50.22	50.35	
6.1	B	14	49.92	50.36	Poor image
10.1	T	11	48.84	49.26	
11.1	B	9	48.59	48.95	
12.05	T	7	48.35	48.55	
13.04	B	8	48.09	48.29	Light clouds
21.04	T	9	45.57	46.24	Clouds
28.0	T	9	43.59	44.16	
29.99	B	8	42.94	43.04	Light clouds
1884 Jan 2.9	B	10	41.56	41.18	
3.9	T	14	41.24	41.19	Very bad
16.9	B	10	37.25	36.92	
20.9	T	11	36.13	36.64	Poor
21.9	B	7	35.88	36.06	Light clouds
22.9	T	10	38 40 35.62	38 40 35.63	Light, hazy clouds

α Lyrae. — Contin.

$\alpha = 18^h 32^m 58^s.64$ $\mu = +0^s.017$. $\delta = 38° 40' 31''.55$ $\mu' = +0''.284$.

Date.	Obsr	Thds	Computed δ	Observed δ	Remarks
1884 Jan 25.9	B	10	38 40 34.77	38 40 34.94	Light clouds
31.9	T	7	32.97	33.29	
Feb 4.9	T	11	32.73	32.77	
15.9	T	5	29.46	29.30	Faint clouds
26.8	B	14	27.49	27.19	
28.8	B	8	27.21	27.13	Poor image
March 24.8	T	9	25.57	25.49	1 1/4" aper.
27.8	B	9	25.61	25.69	Full aper. Light clouds
30.7	B	9	25.86	26.24	Light clouds, unsteady
April 6.7	B	8	26.21	26.28	1 1/4 aper.
11.7	T	8	26.75	26.87	
18.7	T	8	27.69	27.26	
20.7	B	7	27.93	27.12	Clouds
June 18.5	B	9	43.32	42.74	Good 1 1/4 aper.
20.5	B	9	44.02	43.88	
July 3.5	T	9	48.00	47.36	
7.5	B	9	49.26	48.94	
10.5	T	9	50.04	50.06	
12.5	B	3	50.56	50.32	Poor
13.5	T	9	50.84	50.85	
14.5	B	9	51.14	50.71	
18.4	T	9	52.41	52.48	Good 1 1/4 aper.
20.4	B	9	52.99	52.95	Poor
21.4	B	9	53.24	53.20	
22.4	. .	. .	53.49	53.18	
30.4	B	8	38 40 55.50	38 40 55.26	

6365 B. A. C.

$\alpha = 18^h 36^m 14^s.4$. $\delta = 38° 15' 32''.14$ $\mu' = +0''.003$.

Date.	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 May 2.7	I	6	38 15 26.35	38 15 25.38	Faint
6.7	B	8	27.32	27.22	
8.6	B	9	27.85	27.34	
9.6	I	9	28.10	27.04	[illegible]
16.6	I	9	29.67	28.80	
17.6	B	5	29.93	29.29	Good
18.6	I	9	30.22	29.29	
24.6	B	9	32.04	31.78	
Aug 6.4	T	6	53.37	52.51	
7.4	T	9	53.60	52.07	
21.4	T	9	56.47	56.03	
22.4	T	9	56.67	56.04	
Sept 1.3	T	9	58.24	57.22	
3.3	T	9	58.48	58.51	
4.3	T	9	58.62	58.64	
5.3	B	9	58.77	57.71	[illegible]
6.3	T	9	58.92	58.46	[illegible]
7.3	B	10	59.07	58.08	[illegible]
9.3	B	9	38 15 59.34	38 15 58.31	[illegible]

40 Cygni.

$\alpha = 20^h 23^m 14^s.2$. $\delta = 38° 3' 23''.58$ [illegible]

Date.	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 June 1.7	I	9	38 3 24.94	38 3 24.63	
4.6	I	6	25.84	25.34	
8.6	B	. .	38 3 26.99	38 3 27.15	

40 Cygni. — Contin.

$\alpha = 20^h 23^m 14^s.2$. $\delta = 38° 3' 23''.58$ $\mu' = -0''.054$.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 June 11.6	I	7	38 3 27.73	38 3 27.37	
14.6	B	8	28.54	29.05	
21.6	B	9	30.79	30.42	
Sept 27.3	T	9	56.60	56.46	[illegible]
28.3	B	9	56.67	55.12	
Oct 2.3	T	9	57.06	56.93	
8.3	B	9	57.78	57.83	
9.3	T	9	57.85	57.95	[illegible]
10.3	B	7	57.90	57.98	
11.3	T	10	57.94	57.79	
15.3	T	9	58.08	58.34	
16.3	T	10	58.14	58.56	
21.3	B	5	58.50	58.98	
Nov 5.2	B	9	58.29	58.25	[illegible]
1884 June 20.6	B	9	38 3 42.10	38 3 42.12	

10 Lacertae.

$\alpha = 22^h 33^m 60^s.74$. $\delta = 38° 26' 29''.57$ [illegible]

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 June 29.7	I	9	38 26 35.56	38 26 34.84	
July 2.7	I	9	36.16	36.16	
6.7	I	9	37.63	37.67	
10.7	B	9	38.62	38.25	
12.6	B	9	39.15	39.21	[illegible]
13.6	I	9	39.41	38.53	
16.6	I	9	40.40	40.56	
17.6	B	9	40.73	40.79	
22.6	B	6	42.19	42.12	
26.6	B	8	43.33	43.35	
Sept 27.4	T	11	27 1.15	1.18	
28.4	B	11	1.33	1.08	
Oct 2.4	T	11	2.04	1.87	
8.4	B	9	3.34	3.21	
9.4	T	10	3.53	3.55	
10.4	B	9	3.71	4.12	
15.4	B	9	4.42	4.51	
16.4	T	10	4.57	4.67	
19.4	B	9	5.11	5.20	[illegible]
21.3	B	9	5.89	6.13	
26.3	B	10	6.06	6.29	
30.3	T	9	6.39	6.00	
31.3	B	9	6.50	6.50	[illegible]
Nov 1.3	T	9	6.62	7.11	
3.3	T	8	6.86	6.90	[illegible]
5.3	B	9	7.07	6.92	
7.3	B	9	7.20	6.87	[illegible]
12.3	B	9	[illegible]	[illegible]	
14.3	B	10	7.48	7.22	
15.3	T	11	[illegible]	[illegible]	
17.3	T	10	[illegible]	[illegible]	
19.3	B	9	7.77	7.77	
28.3	B	10	7.57	[illegible]	
30.2	B	7	7.58	[illegible]	
Dec 3.2	B	10	38 27 7.51	[illegible]	

10 *Lacertae.* — Contin.

$\alpha = 22^h\,33^m\,60^s.71.\quad \delta = 38°\,26'\,29''.57\quad \mu' = .000.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1880 Dec 6.2	T	10	38 27 7.29	38 26 7.27	
10.2	B	9	6.95	7.30	Light clouds
11.2	T	9	38 27 6.88	38 26 7.21	

32 *Andromedae.*

$\alpha = 0^h\,34^m\,46^s.75.\quad \delta = 38°\,48'\,58''.20\quad \mu' = -0''.012.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1880 July 22.7	B	8	38 49 1.06	38 49 3.57	Clouds, but light clouds
25.7	I	8	1.67	1.25	Unsteady, fairly unsteady
26.7	B	7	1.89	4.63	Fair, light clouds
30.7	I	9	5.91	5.06	Diffuse, fair, steady
31.7	I	9	6.21	6.79	Fair
Aug 2.7	I	9	6.76	6.89	Good
6.6	I	9	7.68	8.35	Bad, unsteady, fair
7.6	I	9	7.89	7.86	Diffuse, fair
12.6	I	9	8.95	9.10	Good
Oct 31.4	B	8	28.01	28.11	Fair, high wind
Nov 1.1	T	7	28.18	27.85	Good
3.1	T	9	28.55	28.11	Bad, unsteady, diffuse, fair
5.4	B	9	38 49 28.92	38 49 28.96	Fair

32 *Andromedae.* — Contin.

$\alpha = 0^h\,34^m\,46^s.75.\quad \delta = 38°\,48'\,58''.20\quad \mu' = -0''.012.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1880 Nov 12.1	B	9	38 49 29.80	38 49 30.21	Tolerable seeing
14.1	B	7	30.05	29.61	Seeing poor
16.4	B	7	30.31	29.46	Seeing fair, blurred
17.4	T	8	30.50	30.56	Good seeing, slightly diffuse
19.4	B	7	30.78	30.42	Seeing fair, better
27.3	T	8	31.31	31.92	Very unsteady
28.3	B	7	31.12	31.41	Fair seeing
30.3	B	6	31.60	32.10	Good seeing
Dec 3.3	B	7	31.89	32.17	Tolerable, image diffuse
5.3	B	7	31.97	30.96	Obs. by double break ocul.
6.3	T	8	32.00	32.29	Fair
10.3	B	7	32.01	32.08	Fair image, high power
11.3	T	8	32.07	32.02	Good seeing, unsteady
12.3	B	6	32.11	32.41	Poor seeing, bad
17.3	B	6	32.31	31.91	Seeing tolerable
21.3	B	8	32.23	32.29	Fair
29.3	T	6	31.99	32.02	Clouds faint, good
1881 Jan 3.2	T	8	31.72	32.09	Unsteady, good image
4.2	B	7	31.68	32.11	Light clouds, faint
6.2	T	7	38 49 31.43	38 49 31.45	Fair

(Continued in No. 264.)

RESULTS OF THE OBSERVATIONS OF α *LYRAE*, MADE DURING THE YEARS 1862–67, WITH THE PRIME-VERTICAL TRANSIT OF THE U. S. NAVAL OBSERVATORY,

By S. NEWCOMB.

I have for some time had lying among the unpublished Astronomical Papers for the use of the *American Ephemeris*, a discussion of the above observations. This discussion was made at a time when no suspicion was entertained that a periodic variation of the latitude could have any other period than that of EULER, about 306 days. Mr. CHANDLER's discovery from observation that the actual period was much longer, and my own explanation of this circumstance by the non-rigidity of the earth, and the mobility of the ocean, necessitated a new formation and solution of the equations of condition. This new solution is just completed, and as I shall not have an opportunity of putting it into definitive shape during the present year, I beg leave to make the results known through the *Astronomical Journal*.

Besides the parallax, aberration, mean declination, and the two quantities depending on the variation of the latitude, it was necessary to include the effect of the sun's rays in changing the refraction at the moment of observation, an effect which I have assumed to be proportional to the cosine of the sun's azimuth when the sun was above the horizon, and to be zero when below it. It was also found necessary to correct the observed declinations for rate of the clock, a circumstance which seems to have been overlooked in the original reductions. The necessary correction was only a fraction of a tenth of a second, and was nearly always positive, the clock having, for the most part, a gaining rate not far from two seconds a day. The results are as follows:

Mean declination of *α Lyrae* for 1865.0, assuming the latitude of the center of the Observatory to be 38° 53′ 39″.25,	38° 39′ 35″.56
Correction to STRUVE's constant of aberration,	+0″.006
Hence, constant of aberration,	20″.451
Parallax of *α Lyrae*,	+0″.24
Coefficient of sun's azimuth in declination,	+0″.507
Coefficient of sine N (defined below),	$s = +0''.086$
Coefficient of cosine N,	$c = -0''.087$

N is here an angle assumed to be zero at the epoch 1864.50, and to increase at the rate of 308° annually.

This motion is based on the hypothesis that the period of the axis of rotation around the axis of figure is 427 days, as found by Mr. CHANDLER. The relative position of the two axes at any time cannot directly appear in the equations, but we may regard the values of c and s as equal to the coordinates of the axis of rotation relatively to that of figure on July 1st, 1864.

The actual expression which thus follows for the variation of the latitude of Washington is

$$\delta\varphi = 0''.122 \cos 308^{\circ}(t-1864.94)$$

Hence the distance of the two poles, or semiamplitude of the variation of latitude, 0″.122.

The epochs at which according to these results, the axis of instantaneous rotation passed the meridians of Pulkowa and of Washington respectively, that is, the epochs of maximum latitude in the case of the two observatories, are as follows:

Washington	Pulkowa
1863.19	1863.54
1864.36	1864.71
1865.53	1865.88
1866.70 etc.	1867.05 etc.

From the manner in which the parallax is connected with the effect of the sun's rays in changing the refraction, an effect which was described in my former paper (*A.J.* No. 251), these quantities are so related that they cannot be determined independently. This seems to be the reason why the parallax now found is larger than that previously derived.

The aberration-constant, which is the main quantity to be determined, is so completely separate from all the others that I have not entered upon a minute discussion of the parallax

ON A NEW VARIABLE STAR IN *LEPUS*,

(6h 0m 36s.8, —24° 11′.1 (1875.0)).

BY EDWIN F. SAWYER.

In connection with my revision of the U. A. magnitudes, I have at various times observed the star 87 U. A. *Leporis*. The large number of estimates secured, between the years 1882 and 1889, had shown discordances of over half a magnitude; and, notwithstanding its low altitude, and somewhat isolated position, which rendered observations rather difficult, I was led to believe that the star fluctuated in its light to a limited extent, and it was marked for a more careful examination, as soon as time would permit. As early as observations could be secured in 1890, the star was looked for and found to be fainter than it had previously been seen. Close watch was then kept of the star during 1891, and its variability soon established beyond doubt. Its magnitude is given by various authorities accessible to me, and kindly furnished by Dr. GOULD as follows: YARNALL $6^{M}.5$; in Dr. GOULD'S zones it occurs three times, 1872 Dec. 10; 1873 Jan. 22 and Dec. 19, and each time estimated at 7^{M}. For the *Argentine Uranometry* it was observed once as $6^{M}.7$, and twice as $7^{M}.0$. The discordance being looked up, the magnitude was found to be $6^{M}.7$ again, and the mean value $6^{M}.9$ was adopted. STONE'S *Cape Catalogue* for 1880, gives for the observation, date 1878.08, and magnitude $7^{M}.6$, which is about $6\frac{2}{3}^{M}$. Its non-occurrence in HEIS'S Catalogue, indicates that he did not estimate it so bright as $6\frac{2}{3}^{M}$. The limits of variation observed by me are from $6^{M}.7$ to $7^{M}.5$, or eighth-tenths of a magnitude.

A careful inspection of all my observations to date strongly indicates a mean period of very nearly 69 days, which however appears subject to deviations. Irregularities are also suspected in the limits of fluctuation. These deviations, if real, would indicate a light curve resembling the *R Scuti* type. The comparison-stars used with their magnitudes are as follows:

		1875.0				Mag.	
		α		δ		G.	S.
		h	m	°	′		
a	79 U.A. *Leporis*	5	51.4	—23	14	6.7	6.7
b	GOULD 7298	6	1.6	24	55	7¼	7.4
c	GOULD 7339	6	3.4	23	24	7¼	7.7

The following table gives all the estimates up to date:

			M				M	
1882	Mar.	13	6.95	1891	Mar.	7	7.5	
1887	Feb.	19	6.7		Dec.	28	6.9	
	"	21	6.9		"	30	6.9	
1888	"	13	7.1	1892	Jan.	21	7.1	
	"	29	7.3		"	31	7.3	
	Mar.	1	7.3		Feb.	1	7.35	
	"	29	7.2		"	4	7.35	
1889	"	23	7.0		"	15	7.40	
1890	Feb.	16	7.5		Mar.	4	7.05	C
	Mar.	18	7.5		"	5	7.0	C
	Dec.	9	7.5		"	14	6.95	
1891	Jan.	8	7.5		"	15	6.97	
	"	12	7.45		"	21	7.0	
	"	30	7.0		"	24	7.05	
	"	31	7.05		"	29	7.1	C
	Feb.	2	7.05		"	30	7.1	C
	"	11	7.20		"	31	7.1	C
	"	27	7.45					

An inspection of the above observations will show that the star was near a maximum on the following dates: 1882 Mar. 13; 1887 Feb. 19–21; 1888 Feb. 13; 1889 Mar. 23; 1891 Jan. 30 and Dec. 28–30; and 1892 Mar. 14–15. The star was near a minimum, 1890 Feb. 16 and Mar. 18, Dec. 9; 1891 Jan. 12, Feb. 27 to Mar. 7, and 1892 Jan. 31 to Feb. 15. Observations at a more southern station, where the star could be longer followed, are desired.

Brighton, Mass., 1892 *April* 11.

NEW ASTRONOMICAL WORK.

Catalogue de l'Observatoire de Paris. — Étoiles observées aux Instruments. Tome II. Positions Observées des Étoiles. Tome II. Paris, 1891.

The second portion of the great Paris Catalogue was issued at the close of September last, and contains the stars situated between $6^h\,0^m$ and $12^h\,0^m$ of right-ascension, 7518 in all.

Its arrangement is entirely similar to that of the first portion, published four years previously, — one volume containing the catalogue proper of the mean places of the stars, as definitely deduced, together with two terms of the precession, and the other giving the several determinations, upon which the final positions of the catalogue depend.

The work thus comprises the results of forty-five years of meridian observations, from 1837 to 1881, and these are divided throughout into three groups:

I. The determinations made during the seventeen years, 1837 to 1853, inclusive, all under the directorship of Arago. These are referred to the mean equinox of 1845.0.

II. Those made during the fourteen years, 1854 to 1867, all under the directorship of LeVerrier. These are referred to the mean equinox of 1860.0.

III. Those made during the fourteen years, 1868 to 1881. Those in 1868, 1869, and 1873 to 1877, were also under the direction of LeVerrier; those of the years 1870 to 1872, under that of Delaunay, and finally those during the period 1878 to 1881, under that of Mouchez. The mean equinox of reference for these is that of 1875.0.

All the computations have been executed and the results arranged for publication, under the able superintendence of Mr. Gaillot, assisted by Mr. Bossert.

Upon assuming the charge of the Observatory in 1854, LeVerrier decided to undertake the re-observation of all the stars in Lalande's zones. For this, the reduction, published by Baily for the British Association in 1847, afforded a very convenient working list. Meanwhile, he provided for the careful computation of all the observations made in previous years since 1837; and all these, as well as those made during his own first period of directorship, were reduced to the form of apparent places at the time of observation.

On Delaunay's accession, the reduction of these apparent places to the corresponding mean positions for the beginning of the year, was systematically undertaken, and this work was completed during the next eleven years.

Admiral Mouchez, upon his appointment, in 1878, resolved to make the vast collection of observations, already accumulated, serviceable to astronomers, who had indeed not been remiss in urging the publication of the results. He therefore availed himself of all the resources at his disposal, not only to complete the work of re-observing Lalande's stars, but to construct a single catalogue from the total mass of material available. The widely distant dates of observation, as well as the continual introduction of improved methods and of more delicate instruments, which had been going on during a period of more than forty years, required the employment of more than one equinox of reference; and the problem was most happily solved by dividing the whole series into three comparatively homogeneous groups already mentioned. For each of these, a nearly middle date affords an equinox, which has already been used for other catalogues of recognized importance.

In this way, the Paris Catalogue has been constructed. It gives for each star, the data corresponding to each of the three groups, side by side, — the epochs of the three equinoxes of reference being 15 years apart. The two opposite pages at each opening exhibit for their respective coordinates, the number of observations, the mean date, and the mean result, together with the two precessional terms, and a comparison of this new Paris value, with that of Baily's Lalande, after application to the latter of the corrections indicated by Argelander and others, and of those reduced from von Asten's reduction-tables.

The facilities for investigating the proper motions, and for the detection of errors, which are afforded by the comparison with Lalande and by the juxtaposition of the places resulting from three different groups of observations, have been most conscientiously and elaborately improved by Mr. Bossert. This thorough investigation of all the discordances brought to light forms in itself an important memoir.

A table is also given indicating the corrections applied to the places in Baily's Lalande, including those disclosed in the course of this work; also another extensive one, showing the results of a comparison of the Paris places with the positions contained in Auwers's Bradley. The degree to which the discrepancies, as given by the three groups, agree with each other, is most instructive, and frequently manifests at a glance, the extent to which the discordances must be attributed to Bradley's observations, and how far it may be reasonable to attribute them to proper motion.

At the side of the current number for a star in the catalogue is that which corresponds to the same star in Baily's Lalande; and stars not occurring in the latter are identified by their numbers in some other well-known catalogue.

The volume of Observed Positions requires little description. It is arranged essentially upon the plan often followed for the separate determinations, in annual collections of observations. The single observations are given after their complete reduction and reference to the equinox of the epoch adopted for the grouping. The mean of all affords the position for the catalogue proper in the other volume. A full description of all the processes employed as well as of the systematic, mean, and probable errors of the results, is given by Mr. Gaillot.

It is interesting to note how large is the number of astronomers who have taken part in the observations. The names of all are recorded in the introduction to the first portion; and it appears that ten different observers furnished the material for the first group; 30, that for the second; and 37, that for the third. But, as 11 are registered in more than one group, we find 26 to be the total number of observers, who have contributed to the catalogue.

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DECLINATIONS OF 36 STARS FROM OBSERVATIONS WITH PRIME-VERTICAL TRANSIT OF THE UNITED STATES NAVAL OBSERVATORY.

Communicated by PROF. STIMSON J. BROWN, U.S.Navy, with the permission of the Superintendent.

(Continued from page 182.)

59 Andromedae. Dble. (obs. larger).

$\alpha = 2^h\,03^m\,47^s.16.$ $\delta = 38°\,29'\,11''.60$ $\mu' = -0''.017.$

Proper motion not applied to computed places.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1882 Dec. 14.4	I	9	38 29 22.73	38 29 21.86	
16.3	I	9	22.87	23.54	
18.3	B	9	22.94	22.43	
19.3	T	7	22.96	22.27	
26.3	I	9	23.35	23.60	
28.3	B	9	23.45	22.20	
1883 Aug. 12.7	I	9	15.52	15.13	Very faint
Sept. 3.6	T	5	20.07	19.90	Clouds. Very faint at times
Nov. 19.4	B	9	34.71	34.59	Good
27.4	T	9	35.58	35.73	
28.4	B	10	35.68	35.50	Good
30.4	B	9	35.92	36.70	Good
Dec. 3.4	B	9	36.34	36.75	Fair
5.4	B	9	36.57	36.38	Good
6.1	T	9	36.65	36.61	Diffuse, unsteady
10.4	B	8	36.89	36.64	Fair
11.4	T	9	36.96	37.11	Faint, diffuse
12.4	B	9	37.04	37.02	Fair
21.3	B	9	37.71	37.68	Fair
27.3	T	8	37.86	38.59	Faint, not good
28.3	B	8	37.91	38.05	Very good
29.3	T	9	37.97	38.36	Very good
1884 Jan. 2.3	B	7	38.12	37.95	Fair, high wind
4.3	B	9	38.10	38.11	Fair
6.3	T	9	38.03	38.63	Good image
9.3	B	8	38.00	37.27	Fair
17.3	T	9	37.95	37.89	Good, bad
21.3	B	9	37.63	37.35	Good
22.2	T	8	38 29 37.57	38 29 37.79	Good, faint

ρ Persei.

$\alpha = 2^h\,57^m\,40^s.85.$ $\delta = 38°\,23'\,09''.26$ $\mu' = -0''.106.$

Proper motion not applied to computed places.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1882 Dec. 7.1	I	9	38 23 15.61	38 23 16.74	
11.4	I	9	16.09	16.29	
13.1	B	9	16.36	16.13	
15.1	B	9	16.59	17.08	
16.1	I	9	16.68	17.15	
18.1	B	9	38 23 16.80	38 23 17.65	

ρ Persei. — Contin.

$\alpha = 2^h\,57^m\,40^s.85.$ $\delta = 38°\,23'\,09''.26$ $\mu' = -0''.106.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1882 Dec. 19.1	I	9	38 23 16.85	38 23 16.29	
26.1	I	9	17.40	17.60	
28.1	B	8	17.58	17.35	
1883 Jan. 2.3	B	9	17.72	17.45	
12.3	I	9	18.15	18.73	
22.3	I	9	18.11	18.20	
21.3	I	9	18.18	18.18	
Feb. 21.2	I	9	16.64	16.65	
July 30.8	I	11	7.31	7.57	
Aug. 2.8	I	11	7.78	7.75	
7.7	I	9	8.37	8.12	
12.7	I	11	8.93	8.70	
Sept. 3.7	T	11	12.46	12.01	
5.7	T	11	12.60	12.38	
9.7	B	11	13.34	12.72	
25.6	B	9	16.22	15.46	
Dec. 6.4	T	8	27.28	27.53	
10.4	B	10	27.59	27.28	
11.1	T	9	27.67	27.63	
12.1	B	9	27.76	27.86	
21.4	B	9	28.69	28.72	
27.3	T	5	28.96	28.91	
28.3	B	9	29.04	29.10	
29.3	T	9	29.13	28.96	
1884 Jan. 2.3	B	9	29.41	30.02	
4.3	B	9	29.49	29.43	
6.3	T	6	29.54	29.59	
9.3	B	9	29.56	29.63	
11.3	T	9	29.85	30.22	
21.3	B	10	29.70	29.36	
22.3	T	9	29.68	29.72	
23.3	B	8	29.67	29.06	
26.3	T	9	29.70	29.83	
Feb. 1.3	B	10	29.5[illegible]	29.90	
15.2	T	9	28.75	28.13	
21.2	T	9	38 23 28.18	38 23 28.18	

50 Persei.

$\alpha = 4^h\,00^m\,48^s.83.$ $\delta = 37°\ 43'\ 55''.98$ $\mu' = -0''.193$

Proper motion not applied to computed places.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1882 Dec. 26.1	I	9	37 43 59.21	37 43 59.29	
1883 Jan. 2.1	B	7	59.73	60.25	
12.4	I	7	44 0.46	44 0.62	
22.3	I	9	0.82	1.00	
24.3	I	9	0.94	0.99	
29.3	I	9	0.99	0.69	
Feb. 1.3	I	9	0.92	1.07	
Sept. 21.7	T	9	43 55.64	43 56.02	
25.7	B	10	55.80	55.74	
26.7	T	9	55.95	55.48	
28.6	T	10	56.21	56.50	
Dec. 27.4	T	10	44 6.50	44 6.55	
28.4	B	5	6.61	7.27	
29.4	T	6	6.71	6.72	
1884 Jan. 9.4	B	9	7.47	7.22	
17.3	T	10	8.07	7.86	
21.3	T	10	8.09	7.87	
22.3	T	10	8.09	8.14	
23.3			8.12	7.73	
26.3	B	9	8.27	8.16	
Feb. 1.3	B	9	8.41	7.58	
2.3	T	9	37 44 8.12	37 44 8.28	

μ Aurigae.

$\alpha = 5^h\,5^m\,25^s.31.$ $\delta = 38°\ 20'\ 39''.52$ $\mu' = -0''.071.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1882 Dec. 13.5	B	9	38 20 36.39	38 20 36.03	
26.4	I	9	37.61	38.65	
28.4	B	9	37.90	37.15	
1883 Jan. 2.4	B	6	38.34	38.25	
12.4	I	8	39.25	39.28	
22.4	I	9	39.92	39.95	
24.4	I	9	40.02	40.42	
29.4	I	9	40.12	40.04	
Feb. 1.3	I	9	40.48	40.52	
12.3	B	9	41.01	40.63	
Sept. 21.7	T	11	32.02	32.20	
25.7	B	9	32.11	31.87	
28.7	T	10	32.39	32.03	
Oct. 3.7	T	6	32.57	31.98	
9.7	B	11	32.97	33.19	
10.7	T	11	33.09	32.93	
15.6	T	9	33.45	34.19	
16.6	B	8	33.48	32.67	
1884 Jan. 17.4	T	10	42.01	42.13	
21.1	B	9	42.16	42.99	
22.4	T	9	42.20	42.31	
23.4	B	9	42.25	42.35	
26.4	T	10	42.19	42.59	
Feb. 1.3	B	9	42.96	42.71	
2.3	T	9	42.99	43.11	
15.3	T	9	38 20 43.55	38 20 43.82	

μ Aurigae. — Contin.

$\alpha = 5^h\,5^m\,25^s.31.$ $\delta = 38°\ 20'\ 39''.52$ $\mu' = -0''.071.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1884 Feb. 20.3	B	9	38 20 43.51	38 20 43.12	
21.3	T	9	43.54	43.15	
28.3	T	9	38 20 43.73	38 20 43.93	

θ Aurigae.

$\alpha = 5^h\,51^m\,44^s.61.$ $\delta = 37°\ 12'\ 10''.39$ $\mu' = -0''.078.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1882 Dec. 13.5	B	8	37 12 3.74	37 12 3.35	
28.5	B	9	5.01	4.47	
1883 Jan. 22.4	I	8	7.01	7.87	
24.4	I	9	7.28	7.58	
29.4	I	9	7.69	7.98	
Feb. 1.4	I	9	7.80	7.67	
9.4	I	9	8.40	8.77	
12.3	B	7	8.62	8.37	
27.3	I	10	9.24	9.09	
28.3	B	10	9.23	8.80	
Mar. 21.2	I	8	9.46	10.09	
Sept. 7.8	T	9	11 58.99	11 58.81	
24.7	T	9	58.93	58.85	
Oct. 3.7	T	9	59.10	58.82	
10.7	T	9	59.25	58.41	
15.7	T	9	59.37	59.24	
16.7	B	9	37 11 59.36	37 11 59.11	

40 Aurigae.

$\alpha = 5^h\,58^m\,31^s.22.$ $\delta = 38°\ 29'\ 29''.60$ $\mu' = -0''.046.$

Proper motion not applied to computed places.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1882 Dec. 13.5	B	8	38 29 22.38	38 29 21.85	
28.5	B	3	23.74	23.34	
1883 Jan. 22.4	I	9	25.98	26.14	
24.4	I	13	26.24	26.28	
29.4	I	9	26.70	26.31	
Feb. 1.4	I	9	26.83	26.79	
8.4	B	7	27.50	28.28	
9.4	I	13	27.59	27.46	
12.4	B	12	27.76	27.54	
19.3	I	13	28.11	28.03	
21.3	B	11	28.29	27.99	
28.3	B	11	28.50	27.40	
Mar. 1.3	I	12	28.51	28.44	
2.3	B	5	28.54	28.23	
3.3	I	10	28.57	28.31	
7.3	B	10	28.82	28.65	
Oct. 8.7	T	11	17.29	17.65	
9.7	B	10	17.34	17.75	
10.7	T	11	17.39	17.65	
16.7	B	10	17.50	17.75	
30.6	B	8	17.86	18.36	
31.6	T	10	17.85	17.81	
Nov. 1.6	B	8	17.85	18.18	
4.6	B	8	17.96	18.27	
5.6	T	9	38 29 18.04	38 29 17.98	

40 Aurigae. — Contin.

$\alpha = 5^h\ 58^m\ 31^s.22.$ $\delta = 38°\ 29'\ 29''.60$ $\mu' = -0''.046.$

Proper motion not applied to computed places.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
			° ′ ″	° ′ ″	
1884 Feb 1.4	B	10	38 29 25.03	38 29 25.41	
2.4	T	9	25.21	25.30	
15.3	T	9	26.19	26.40	
18.3	B	8	26.27	26.33	
20.3	B	10	26.34	25.89	
21.3	T	9	26.40	26.32	
28.3	T	6	26.90	26.95	
Mar. 4.3	T	9	26.90	27.16	
6.3	T	9	26.96	26.90	
15.3	T	9	38 29 27.18	38 29 27.63	

65 Aurigae.

$\alpha = 7^h\ 14^m\ 13^s.51.$ $\delta = 36°\ 58'\ 44''.88$ $\mu' = -0''.030.$

Proper motion not applied to computed places.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Feb 9.4	I	9	36 58 37.31	36 58 37.83	
19.4	I	9	38.12	37.87	
21.4	B	9	38.38	37.89	
28.4	B	9	38.95	39.07	
Mar 1.4	I	11	39.00	38.57	
3.4	I	10	39.14	38.72	
7.4	B	9	39.58	39.55	
8.3	I	10	39.67	38.47	
13.3	I	10	39.93	39.62	
Oct 29.7	T	9	25.65	25.61	
30.7	B	9	25.57	25.71	
31.7	T	9	25.48	25.57	
Nov 1.7	B	11	25.40	25.51	
4.7	B	5	25.24	25.10	
6.7	B	9	25.23	25.41	
12.7	T	9	25.12	25.26	
13.7	B	11	25.05	25.03	
15.7	B	7	24.93	24.69	
16.6	T	10	24.88	24.68	
19.6	T	10	24.86	25.48	
27.6	B	8	24.88	25.19	
28.6	T	9	24.84	25.45	
30.7	T	6	24.80	25.41	
1884 Mar 10.3	B	11	32.31	32.21	
15.3	T	9	36 58 32.66	36 58 32.76	

60 Aurigae.

$\alpha = 6^h\ 45^m\ 11^s.87.$ $\delta = 38°\ 34'\ 56''.75$ $\mu' = -0''.181.$

Proper motion not applied to computed places.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Feb 21.4	B	12	38 34 52.53	38 34 52.12	
23.4	B	11	52.71	52.12	
Mar 1.4	I	13	53.04	52.83	
2.4	B	11	53.09	52.44	
3.3	I	10	53.15	52.97	
7.3	B	10	53.51	53.66	
8.3	I	10	53.61	53.28	
13.3	I	10	53.77	53.54	
Oct 29.7	T	10	39.77	40.02	
30.7	B	8	39.74	40.03	
31.7	T	11	39.69	39.67	
Nov 1.7	B	6	38 34 39.64	38 34 40.12	

60 Aurigae. — Contin.

$\alpha = 6^h\ 45^m\ 11^s.87.$ $\delta = 38°\ 34'\ 56''.75$ $\mu' = -0''.181.$

Proper motion not applied to computed places.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
			° ′ ″	° ′ ″	
1883 Nov 4.7	B	8	38 34 39.60	38 34 39.25	
5.7	T	9	39.62	39.50	
6.7	B	9	39.65	40.39	
12.6	T	10	39.73	39.84	
14.6	T	11	39.68	40.26	
16.6	T	9	39.64	40.06	
18.6	B	6	39.68	39.37	
27.6	B	8	39.98	40.03	
28.6	T	9	39.98	40.64	
29.6	. .	. .	39.99	39.53	
30.6	T	9	40.01	40.58	
1884 Feb 18.4	B	10	46.80	46.76	
20.4	B	10	46.91	46.22	
21.4	T	9	47.01	47.21	
28.3	T	7	47.73	47.40	
Mar 4.3	T	9	47.91	47.73	
15.3	T	9	48.60	48.59	
22.3	T	9	38 34 48.57	38 34 48.67	

38 Lyncis.

$\alpha = 9^h\ 11^m\ 35^s.66.$ $\delta = 37°\ 17'\ 48''.48$ $\mu' = -0''.114$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Feb 23.16	B	9	37 17 35.37	37 17 35.71	
26.15	B	8	35.80	35.27	
28.4	B	8	36.01	35.50	
Mar 1.4	I	11	36.11	35.38	
3.4	I	10	36.32	36.14	
13.4	I	10	37.76	38.23	
22.4	I	10	38.96	38.32	
Apr 7.3	I	10	40.89	41.23	
21.3	I	9	42.18	42.08	
Oct 29.8	T	9	22.17	22.54	
Nov 12.7	T	8	20.03	19.75	
14.7	T	11	19.68	19.10	
16.7	T	9	19.32	18.28	
18.7	B	9	19.04	19.28	
19.7	T	11	18.92	19.36	
27.7	B	9	18.12	17.85	
28.7	T	9	17.99	17.76	
29.7	B	10	17.86	17.19	
30.7	T	9	17.71	18.01	
Dec 3.7	T	7	37 17 17.44	37 17 17.62	

Lalande 18362.

$\alpha = 9^h\ 13^m\ 39^s.40.$ $\delta = 38°\ 40'\ 57''$.[illegible]

Proper motion not applied to computed places.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Feb 26.45	B	10	38 40 45.38	38 40 45.40	
Mar 20.4	I	10	48.37	48.89	
21.4	B	10	48.54	48.75	
22.4	I	10	48.71	49.02	
24.4	I	10	49.04	48.62	
Apr 3.4	I	10	50.19	49.93	
4.3	B	6	50.35	50.55	
7.3	I	10	50.74	50.57	
10.3	I	10	50.98	50.93	
13.3	B	9	38 40 51.18	38 40 50.21	

Lalande 18362. —Contin.

$\alpha = 9^h\ 13^m\ 39^s.10.$ $\delta = 38°\ 40'\ 57''.93$ $\mu' = -0''.02.$

Proper motion not applied to computed places

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Apr 14.3	I	10	38 40 51.28	38 40 50.86	
17.3	I	10	51.61	50.94	
18.3	B	10	51.77	51.53	
20.3	B	8	51.99	51.99	
Dec 3.7	T	9	26.17	26.78	
9.7	B	9	26.06	25.33	
10.7	T	9	26.05	26.58	
27.6	B	9	25.33	25.19	
28.6	T	9	25.30	25.78	
1884 Jan 2.6	T	9	25.42	25.80	
9.6	T	7	25.53	25.94	
13.6	B	9	25.65	25.64	
17.6	B	10	26.02	26.35	
21.5	T	8	26.29	26.55	
April 7.3	B	9	36.05	35.64	
18.3	B	7	38 40 37.09	38 40 37.01	

38 Leonis Minoris.

$\alpha = 10^h\ 32^m\ 26^s.62.$ $\delta = 38°\ 31'\ 9''.97$ $\mu' = -0''.01.$

Proper motion not applied to computed places

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Mar 21.4	B	6	38 30 57.27	38 30 57.21	
22.4	I	7	57.49	57.36	
24.4	I	10	57.90	57.58	
April 10.4	I	10	31 0.69	0 0.49	
11.4	B	7	0.84	1.85	
14.4	I	10	1.19	0.73	
17.4	I	10	1.70	1.77	
18.4	B	9	1.89	1.67	
20.4			1.25	1.78	
21.4	I	7	2.42	1.95	
24.3	I	9	2.80	2.82	
25.3	B	10	2.90	3.16	
30.3	B	8	3.48	3.40	
May 2.3	B	7	3.78	3.40	
3.3	I	9	3.92	3.76	
4.3	B	9	4.06	3.09	
Nov 27.7	B	10	37.15	37.65	
28.7	T	11	36.95	37.41	
30.7	T	9	36.52	36.76	
Dec 3.7	T	6	35.98	36.56	
9.7	B	9	35.19	34.99	
10.7	T	9	35.04	35.36	
27.7	B	10	33.10	32.94	
28.7	T	10	33.00	33.86	
1884 Jan 2.7	T	9	32.74	33.32	
9.7	T	8	32.47	32.52	
13.6	B	8	32.33	32.41	
17.6	B	9	32.48	32.47	
20.6	B	11	32.60	32.68	
21.6	T	7	32.61	32.55	
Apr 17.4	T	9	44.38	44.12	
18.4	B	9	44.53	44.30	
28.3	B	9	38 31 45.94	38 0 45.51	

Groombridge 1931.

$\alpha = 12^h\ 44^m\ 37^s.04.$ $\delta = 38°\ 09'\ 13''.34$ $\mu' = +0''.02.$

Proper motion not applied to computed places

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Mar 2.4	B	9	38 9 5.91	38 9 5.55	
17.4	I	9	8.92	8.49	
19.4	I	9	9.36	9.90	
24.4	I	9	10.09	9.87	
25.4	B	9	10.28	10.09	
1884 Jan 2.7	T	8	8 37.72	38.34	
13.7			36.08	36.32	
21.7	B	4	35.54	35.75	
Feb. 15.6	T	5	35.26	35.42	
20.6	T	10	35.60	35.82	
26.6	B	10	36.10	35.92	
28.6	B	8	38 8 36.38	38 9 36.23	

Groombridge 1961.

$\alpha = 13^h\ 04^m\ 15^s.09.$ $\delta = 38°\ 02'\ 48''.61$ $\mu' = +0''.004$

Proper motion not applied to computed places

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 May 2.4	B	9	38 2 44.06	38 2 40.47	
16.4	B	9	44.01	43.78	
17.4	I	9	44.26	43.67	
19.4	I	9	44.73	44.47	
24.4	I	9	45.59	45.53	
25.4	B	9	45.75	46.08	
1884 Jan 2.8	T	6	44.21	44.23	
13.7	B	8	42.42	42.62	
20.7	B	7	41.80	41.80	
21.7	T	9	41.74	42.04	
Feb 15.6	T	9	41.07	41.64	
20.6	B	9	41.35	41.86	
26.6	B	3	38 2 41.77	38 2 41.85	

γ Bootis.

$\alpha = 14^h\ 27^m\ 22^s.00.$ $\delta = 38°\ 49'\ 13''.73$ $\mu' = +0''.153.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 May 17.45	I	7	38 49 10.01	38 49 9.80	
19.4	I	7	10.59	10.46	
24.4	I	7	11.80	12.07	
31.4	I	7	13.40	13.59	
June 1.4	B	7	13.66	13.78	
4.4	B	6	14.57	14.33	
6.4	B	7	14.77	14.47	
22.4	B	7	17.81	17.96	
23.4	B	7	17.95	17.60	
July 14.3	I	9	20.80	20.75	
21.3	I	9	21.17	21.52	
25.3	B	9	21.44	22.08	
31.2	I	9	21.66	22.34	
Aug. 6.2	I	9	21.63	22.45	
Dec 27.8	B	6	48.79	49.04	
1884 Jan 13.8	B	7	44.60	44.95	
20.8	B	7	43.55	43.87	
Feb 15.7	T	6	40.98	41.64	
26.7	B	6	38 49 41.07	38 49 41.61	

γ *Bootis.*—Contin.

$\alpha = 14^h\,27^m\,22^s.00.\quad \delta = 38°\,49'\,13''.73\quad \mu' = +0''.153.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1884 Feb 28.7	B	7	38 19 41.23	38 49 41.24	
March 21.6	T	7	43.66	44.40	
24.6	T		44.14	44.17	
30.6	B		45.41	45.16	
April 6.6	B		38 49 46.67	38 49 46.99	

25 *Herculis.*

$\alpha = 16^h\,21^m\,14^s.13.\quad \delta = 37°\,39'\,39''.86\quad \mu' = -0''.02.$

Proper motion not applied to computed places

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 June 27.4	B	9	37 39 47.86	37 39 47.06	
July 1.4	I	9	48.94	49.38	
2.4	B	8	49.18	49.44	
3.4	I	9	49.11	48.55	
4.4	B	9	49.61	50.12	
10.4	I	9	50.78	50.82	
14.4	T	9	51.73	51.89	
17.4	I	10	52.32	52.74	
18.4	B	9	52.47	52.66	
21.4	I	8	52.89	53.30	
1884 Mar. 27.7	B	8	19.58	19.55	
30.7	B	8	20.07	19.66	
April 4.6	I	9	20.72	20.83	
6.6	B	9	21.00	20.66	
11.6	T	9	22.03	21.92	
18.6	T	9	37 39 23.13	37 39 23.19	

ζ¹ *Lyrae.*

$\alpha = 18^h\,40^m\,44^s.53.\quad \delta = 37°\,28'\,59''.99\quad \mu' = +0''.020$

Proper motion not applied to computed places

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 May 2.7	I	9	37 28 54.08	37 28 54.23	
3.7	B	9	54.28	53.92	
8.6	B	9	55.55	55.42	
15.6	B	9	57.10	57.43	
16.6	I	7	57.35	57.84	
17.6	B	7	57.61	57.13	
18.6	I	7	57.89	57.15	
24.6	B	7	59.66	59.62	
July 31.4	T	9	29 19.67	29 20.14	
Aug 1.4	T	9	19.91	20.40	
7.4	T	9	21.48	20.75	
21.4	T	9	24.08	23.56	
22.4	T	9	24.28	24.66	
Sept 1.3	T	9	25.88	26.36	
3.3	B	9	26.12	26.57	
5.3	B	9	26.11	25.94	
6.3	T	9	26.57	26.26	
1884 Apr 27.7	B	9	37 29 58.27	37 29 57.94	

θ *Lyrae.*

$\alpha = 19^h\,12^m\,18^s.40.\quad \delta = 37°\,55'\,33''.08$ [illegible]

Proper motion not applied to computed places

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 May 2.7	I	7	37 55 27.48	37 55 27.06	
8.7	B	7	37 55 28.83	37 55 28.44	

θ *Lyrae.*—Contin.

$\alpha = 19^h\,12^m\,18^s.40.\quad \delta = 37°\,55'$ [illegible]

Proper motion not applied to computed places

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 May 15.7	B	7	37 55 30.30	37 55 30.28	
16.7	I	9	30.52	30.71	
17.6	B	6	30.76	30.75	
18.6	I	9	31.03	30.79	
23.6	I	9	32.16	32.49	
24.6	B	6	32.74	32.83	
31.4	T	9	53.18	53.82	
Aug 1.4	T	9	53.43	53.90	
6.4	T	9	54.59	55.60	
7.4	T	9	54.84	54.76	
21.4	T	9	58.08	57.89	
22.4	T	9	58.51	58.67	
Sept 4.1	T	9	56 0.22	56 0.80	
3.3	B	9	0.51	0.73	
4.3	T	9	0.67	1.49	
5.3	B	9	0.85	59.93	
6.3	T	9	1.04	1.56	
15.3	T	6	2.18	2.13	
Oct 2.3	T	10	3.16	4.45	
9.2	T	6	37 56 3.81	37 56 4.90	

22 *Cygni.*

$\alpha = 19^h\,51^m\,40^s.86.\quad \delta = 38°\,10'\,31''.50$ [illegible]

Proper motion not applied to computed places

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 May 16.7	I	6	38 10 32.04	38 10 31.72	
18.7			32.48	32.38	
23.7	I	6	33.81	33.70	
June 1.6	I	9	36.07	36.33	
4.6	I	9	37.02	36.90	
5.6	B	7	37.33	37.52	
8.6	I	9	38.19	37.69	
11.6	B	7	38.96	38.82	
Sept 1.4	T	9	11 2.57	11 2.76	
3.4	B	9	2.90	3.10	
4.4	T	7	3.11	3.77	
5.4	B	9	3.32	2.38	
6.4	T	9	3.51	3.50	
7.4	B	9	3.75	3.44	
Oct 9.3	T	7	7.53	8.22	
11.3	T	10	38 11 7.56	38 11 7.8[illegible]	

τ *Cygni.*

$\alpha = 20^h\,10^m\,7^s.27.$ [illegible]

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 May 16.7	I	7	37 32 [illegible]	[illegible]	
17.7	B	8	[illegible]	[illegible]	
18.7	I	8	[illegible]	[illegible]	
4.7	I	9	49.21	48.21	
14.7	B	8	[illegible]	[illegible]	
29.6	I	9	56.07	[illegible]	
Sept 20.1	B	8	33 19.54	[illegible]	
26.1	B	9	37 33 21.1[illegible]	[illegible]	

τ Cygni. — Contin.

$\alpha = 21^h\,10^m\,7^s.27.$ $\delta = 37^\circ\,32'\,47''.12$ $\mu' = +0''.460.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Oct 2.4	T	9	37 33 21.90	37 33 21.36	
8.3	B	9	22.54	22.03	
9.3	T	10	22.65	22.57	
10.3	B	9	22.65	22.99	
16.3	T	9	23.24	23.07	
21.3	B	6	23.98	24.07	
26.3	B	9	24.01	23.63	
30.3	T	9	24.08	24.66	
Nov 1.3	T	8	24.19	24.04	
5.3	B	9	24.31	24.15	
7.3	B	9	24.27	24.99	
14.2	B	5	24.04	24.93	
15.2	T	5	24.04	23.91	
16.2	B	8	24.03	24.82	
17.2	T	8	24.02	24.53	
19.2	B	11	23.91	24.78	
Dec 3.2	B	9	22.56	23.41	
6.2	T	9	22.05	22.20	
12.2	T	6	37 33 21.17	37 33 21.27	

72 Cygni.

$\alpha = 21^h\,29^m\,29^s.90.$ $\delta = 38^\circ\,00'\,35''.23$ $\mu' = +0''.084.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 June 21.6		5	38 0 43.38	38 0 43.36	
July 2.6	I		44.39	44.81	
6.6	I	9	45.65	45.16	
Sept 20.4	B	9	1 7.20	1 7.64	
26.4	B	7	8.52	8.32	
Oct 2.4	T	6	9.39	9.68	
8.3	B	7	10.45	10.70	
10.3	B	8	10.70	11.62	
11.3	T	8	10.80	11.59	
16.3	T	6	11.18	11.87	
19.3	B	8	11.70	13.06	
24.3	B	6	12.18	13.22	
30.3	T	8	12.39	13.05	
Nov 1.3	T	8	12.50	13.27	
3.3	T	8	12.73	13.22	
5.3	B	7	12.73	13.41	
7.3	B	8	12.73	12.68	
12.3	B	9	12.60	13.17	
17.2	T	6	38 1 12.65	38 1 13.23	

1 Lacertae.

$\alpha = 22^h\,10^m\,52^s.59.$ $\delta = 37^\circ\,9'\,59''.13$ $\mu' = -0''.00.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 June 29.7	I	9	37 10 6.22	37 10 5.42	
July 2.6	I	9	7.16	6.46	
6.6	I	9	8.36	7.10	
Sept 26.4	B	6	31.36	31.63	
27.4	T	10	31.58	31.41	
28.4	B	9	31.71	31.00	
Oct 2.4	T	8	32.36	32.23	
8.4	B	9	33.55	33.32	
9.4	T	9	33.72	33.51	
10.4	B	9	37 10 33.87	37 10 33.92	

1 Lacertae. — Contin.

$\alpha = 22^h\,10^m\,52^s.59.$ $\delta = 37^\circ\,9'\,59''.13$ $\mu' = -0''.00.$

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Oct 15.4	B	9	37 10 34.49	37 10 34.81	
16.4	T	11	34.62	34.41	
19.3	B	9	35.10	35.62	
21.3	B	9	35.76	35.63	
26.3	B	9	35.90	37.05	
30.3	T	10	36.14	36.44	
31.3	B	7	36.23	36.10	
Nov 1.3	T	9	36.31	36.14	
3.3	T	9	36.53	37.04	
5.3	B	9	36.68	36.06	
12.3	B	9	36.81	36.72	
14.3	B	10	36.88	37.32	
15.3	T	9	36.94	36.97	
17.3	T	11	37.03	36.98	
19.3	B	10	37.06	37.12	
27.2	T	9	36.69	36.40	
30.2	B	9	36.62	37.92	
Dec 3.2	B	7	36.47	36.63	
6.2	T	9	36.17	36.55	
11.2	T	9	37 10 35.82	37 10 36.10	

14 Andromedae.

$\alpha = 23^h\,35^m\,32^s.00.$ $\delta = 38^\circ\,35'\,37''.08$ $\mu' = -0''.077.$

Proper motion not applied to computed places

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 July 10.7	B	9	38 35 43.81	38 35 44.05	
13.7	I	9	44.52	43.67	
16.7	I	9	45.38	45.24	
17.7	B	7	45.68	44.88	
25.6	I	9	47.81	46.77	
26.6	B	5	48.08	47.35	
30.6	I	9	49.33	49.67	
31.6	I	9	49.65	50.21	
Aug 2.6	I	9	50.26	50.37	
Oct 8.4	B	9	36 8.14	36 8.36	
9.4	T	11	8.36	8.59	
10.4	B	8	8.57	8.43	
15.4	B	9	9.42	9.72	
16.4	T	11	9.59	9.44	
19.4	B	11	10.20	10.50	
24.4	B	9	11.15	11.84	
26.4	B	9	11.40	11.66	
31.4	B	6	11.98	10.80	
Nov 1.4	T	9	12.12	12.74	
3.4	T	9	12.44	12.33	
5.4	B	9	12.74	12.50	
12.3	B	8	13.32	13.56	
14.3	B	8	13.50	13.10	
15.3	T	9	13.61	13.59	
17.3	T	9	13.83	13.84	
19.3	B	8	14.01	14.11	
27.3	T	9	14.17	14.68	
28.3	B	6	14.20	14.10	
30.3	B	5	14.30	15.42	
Dec 4.3	T	9	14.38	14.34	
6.3	T	9	14.33	14.40	
11.3	T	9	14.13	14.06	
12.3	B	8	38 36 14.12	38 36 14.36	

Bradley 294. — Comp. to *59 Androm.*

$\alpha = 2^h\,3^m\,48^s$. $\delta = 38°\,29'\,25''.42$ $\mu' = -0.022$.

Proper motion not applied to computed places.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1882 Dec. 18.3	B	7	38 29 36.77	38 29 36.59	
19.3	I	9	36.79	36.17	
26.3	I	9	37.18	37.11	
28.3	B	9	37.28	36.86	
1883 Aug. 12.7	I	9	29.36	29.21	
Nov. 19.4	T	4	48.55	48.46	
27.4	B	9	49.33	49.78	
28.4	T	9	49.52	49.52	
30.4	B	10	49.77	50.79	
Dec. 3.4	B	8	50.18	50.86	
5.4	B	9	50.41	50.08	
6.4	T	9	38 29 50.50	38 29 50.15	

Bradley 294. — Contin.

$\alpha = 2^h\,3^m\,48^s$. $\delta = 38°\,29'\,25''.42$ $\mu' = -0.022$.

Proper motion not applied to computed places.

Date	Obsr	Thds	Computed δ	Observed δ	Remarks
1883 Dec. 10.4	B	8	38 29 50.71	38 29 50.62	
11.4	T	9	50.80	50.81	
21.3	B	9	51.58	51.47	
27.3	T	9	51.70	52.03	
28.3	B	8	51.73	51.66	
29.3	T	9	51.82	51.55	
1884 Jan. 2.3	B	6	51.96	52.11	
6.3	T	7	51.88	52.25	
9.3	B	7	51.85	51.32	
17.3	T	9	51.60	51.57	
21.3	B	9	51.48	51.28	
22.2	T	7	38 29 51.41	38 29 51.44	

The following additional observations have been found since the preceding ones were arranged:

μ Andromedae.	1883 Dec. 7.3	37° 52′ 6″.91	37° 52′ 5″.61	*π Herculis.*	1883 July 21.4	36° 56′ 14″.60	36° 56′ 15″.11
1450 Groomb..	Feb. 26.4	38 24 48 .76	38 24 49 .09	*θ Herculis.*	June 27.5	37 16 9 .47	37 16 8 .65
10 *Leonis min.*.	Mar. 14.4	36 54 47 .06	36 54 46 .50	"	Sept. 6.3	23 .71	23 .82
"	21.4	48 .04	48 .03	6365 *B.A.C.*.	Apr. 27.7	38 15 25 .51	38 15 24 .19
"	24.4	48 .51	47 .66	"	July 31.4	52 .10	52 .25

OBSERVATIONS OF COMETS,

MADE WITH THE 15-INCH EQUATORIAL OF THE HARVARD COLLEGE OBSERVATORY.

By O. C. WENDELL, Assistant.

[Communicated by Professor Edward C. Pickering, Director.]

1891 Cambridge M.T.	✱	No. Comp.	☄ — ✱ Δα	☄ — ✱ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
			Comet 1891 II.					
Sept. 9 11 20 53	1	5	+1 31.28	+12 18.6	3 51 33.30	+22 31 28.5	n9.667	0.698
10 11 11 0	2	5	−1 33.51	− 1 12.3	3 53 37.13	+22 11 53.1	n9.653	0.678
12 11 17 2	3	5	−1 22.92	− 7 23.1	3 57 31.38	+21 35 11.8	n9.663	0.702
14 11 8 20	1	5	+0 33.61	− 4 15.2	4 1 19.40	+20 54 3.9	n9.662	0.709
16 11 17 22	5	5	−0 39.27	− 2 36.1	4 5 0.44	+20 10 12.3	n9.660	0.698
26 11 42 1	6	5	−1 8.29	− 2 0.7	4 21 0.23	+16 1 38.9	n9.612	0.692
Nov. 24 10 52 48	7	5	−1 37.16	− 2 37.7	4 28 53.38	−11 50 17.5	n9.190	0.657
Dec. 8 10 37 50	8	5	+1 11.83	− 6 7.0	4 19 54.71	−11 22 5.9	n8.799	0.618
28 9 40 29	9	5	−1 24.60	− 1 2.9	4 14 21.34	−11 29 51.3	n7.968	0.614
1891 Jan. 20 10 19 33	10	5	−0 51.56	− 7 11.1	4 21 4.79	−11 11 5.1	9.429	0.837
			Comet *d* 1891 (*Tempel-Swift*) = 1891 V					
1891 Oct. 28 8 34 18	11	5	+1 30.37	−10 3.2	21 16 55.21	+ 5 40 15.8	9.293	0.726
Nov. 2 10 6 11	12	5	−2 11.68	+ 1 55.5	21 28 52.69	+ 7 29 7.8	9.538	0.722
3 8 11 41	13	5	−1 5.96	− 5 11.6	21 31 22.02	+ 7 50 31.7	9.249	0.703
4 8 30 56	14	6	+1 7.66	+ 8 30.3	21 34 12.39	+ 8 14 23.7	9.319	0.704
6 8 46 18	15	5	−0 18.04	+13 7.6	21 40 11.68	+ 9 3 15.9	9.376	0.700
27 8 21 34	16	5	−2 7.77	+ 2 11.9	23 16 18.79	+19 32 29.1	9.272	0.756
			Comet *a* 1892 (*Swift*)					
1892 Mar. 20 16 51 0	17	7	−0 31.01	− 6 24.3	20 2 54.07	−18 46 11.8	n9.544	0.85[illegible]
29 16 50 12	18	5	+1 56.56	+ 2 52.3	20 40 21.66	− 9 23 32.7	9.524	0.817
			Comet *c* 1892 (*Denning*)					
Mar. 19 9 12 35	19	5	−1 2.77	−11 58.4	22 47 39.51	+59 19 25.3	9.579	[illegible]
21 9 33 11	20	5	+2 18.38	+ 3 13.8	22 59 59.23	+59 10 30.5	9.504	[illegible]

Mean Places for 1891.0 and 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 50 0.21	+1.78	+22 22 0.7	+ 9.2	Rümker 3^h 1033
2	3 55 9.15	+1.79	+22 16 26.2	+ 9.2	" 3^h 1062
3	3 58 52.46	+1.84	+21 12 55.4	+ 9.5	W. Bessel III 1215
4	4 0 13.90	+1.89	+20 58 9.1	+10.0	" III 1266
5	4 5 37.17	+1.91	+20 12 38.0	+10.4	7 comps. with B.B. VI. +20° 704
6	4 22 6.42	+2.10	+16 3 27.8	+11.8	Piazzi IV 86
7	4 30 27.43	+3.11	−11 17 52.9	+13.4	Schjellerup 1471.
8	4 18 39.69	+3.19	−14 16 9.5	+10.6	W. Bessel IV 346
9	4 15 42.72	+3.22	−14 28 55.4	+ 6.9	" IV 282
10	4 21 56.05	+0.30	−11 33 50.3	− 1.0	" IV 426
11	21 15 23.08	+1.76	+ 5 50 6.2	+12.8	B.B. VI +5° 1761
12	21 31 2.63	+1.74	+ 7 23 58.4	+13.9	W. Bessel XXI 692
13	21 32 26.25	+1.73	+ 7 55 59.3	+14.0	" XXI 723
14	21 33 3.01	+1.72	+ 8 5 39.2	+14.2	" XXI 745
15	21 40 57.98	+1.74	+ 8 50 23.6	+14.7	" XXI 916
16	23 18 24.57	+1.99	+19 29 26.4	+20.8	Rümker 11409.
17	20 3 28.79	−0.71	−18 39 39.1	− 8.1	Oe. Arg. 20271–5
18	20 38 25.73	−0.63	− 9 26 14.4	−10.6	Schjellerup 8246
19	22 18 45.15	−2.87	+59 31 35.6	−11.9	Oe. Arg. 24834–6
20	22 57 13.99	−3.14	+59 36 58.2	−11.5	Groombridge 3959

OBSERVATIONS OF COMET *a* 1892 (*SWIFT*),

MADE AT THE HAVERFORD COLLEGE OBSERVATORY WITH THE 10-INCH EQUATORIAL.

BY PROF. F. P. LEAVENWORTH, GEO. L. JONES, AND WM. H. COLLINS.

1892 Haverford M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$		Obs.
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ	
d h m s			m s	′ ″	h m s	° ′ ″			
Mar. 28 17 7 32	1	1 , 3	−3 21.28	+5 15.8	20 36 27.27	−10 25 40.4	*n*9.518	0.808	L
29 16 36 38	2	4 , 3	−6 25.29	+0 5.7	20 40 23.79	− 9 23 22.7	*n*9.556	0.797	J
Apr. 11 16 7 8	3	7 , 5	+1 26.84	−1 50.7	21 29 11.57	+ 4 3 1.2	*n*9.592	0.712	C
16 15 30 50	4	3	+5 31.28	. . . .	21 46 31.42	. . . .	*n*9.628	. .	C
15 30 50	5	3	+5 17.30	. . . .	21 46 31.25	. . . .	*n*9.628	. .	C
15 50 10	5	2	. . . .	−1 58.0	. . . . .	+ 8 45 51.4	. . .	0.710	C

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	20 39 19.21	−0.65	−10 30 46.3	−10.2	Yarnall (F) 9271
2	20 46 49.73	−0.65	− 9 23 18.1	−10.3	American Ephemeris, 1892
3	21 27 15.30	−0.58	+ 4 5 4.6	−12.6	Ast. Ges. (Albany) 7535
4	21 41 0.70	−0.55	+ 8 50 36.9	−13.0	½(Seeliger, Vol. I, 29171 + Lamont 6137)
5	21 41 11.50	−0.55	+ 8 48 2.3	−13.0	½(Seeliger, Vol. I, 29182 + Lamont 6139)

Observations on April 16 stopped by clouds.

A comparison with the ephemeris in *A.J.*, no. 262, gives the errors

O — C April 11 $\Delta\alpha$, -5^s $\Delta\delta$, $-2'$

" 16 -7 -7

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THE

ASTRONOMICAL JOURNAL.

No. 265.

VOL. XII. BOSTON, 1892 MAY 10. NO. 1.

ON THE CHIEF CAUSE OF THE ANOMALIES IN THE LIGHT-VARIATIONS OF *Y CYGNI*.

By N. C. Dunér.

Since obtaining the first observations of this star in April, 1891, I have observed it as often as possible, and have at present observations in every month from April 1891 to April 1892, inclusive, except the summer months, May, June and July. By the end of February of this year, the evening observations nevertheless had retrograded too far into the twilight to permit their continuance. In the discussion of the whole material from observation, however, it became evident that a systematic difference must be assumed between the even and the odd epochs, so that the interval of time, between an even epoch and the next following uneven one, amounts, not to 1^d 12^h, but only to about 1^d 8^h.5; while, inversely, the interval from an odd epoch to the succeeding even one, is 1^d 15^h.5. Were this assumption correct, observations of the odd epochs could be successfully made during the morning hours in March. This proved, in fact, correct, and I was enabled to determine a minimum-epoch, March 20, and also two others on March 29 and April 4. The whole number of minima determined by me amount, therefore, to 27, as follows:

Epoch	Mean Time, Upsala		d	h	m	Remarks
1058	1891	April	12	15	22	Very uncertain
1066			24	15	2	Not quite certain
1134		Aug.	1	11	40	Very good
1136			7	11	42	" "
1144			19	11	23	" "
1150			28	11	12	Not very uncertain
1152			31	11	3	Very good
1154		Sept.	3	11	3	" "
1158			9	10	17	" "
1160			12	10	51	Very uncertain
1162			15	11	6	Very good
1168			24	10	19	" "
1172			30	10	39	Moderately good
1176		Oct.	6	10	22	Somewhat uncertain
1180			12	9	58	Very good
1182			15	9	59	Rather uncertain
1184			18	9	45	Quite good
1188			24	9	7	" "
1191	1891	Nov.	2	9	30	Very good
1228		Dec.	23	7	36	Good
1236	1892	Jan.	1	8	4	Good
1260		Feb.	9	6	46	Pretty good
1268			21	6	57	" "
1270			24	6	19	" "
1287		Mar.	20	13	41	Very uncertain
1293			29	12	28	Moderately good
1297		April	4	12	44	" "

Besides the above, I have received four other observations: namely, one by the assistant of this observatory, Cand. Nordenmark, who observed with me, but without knowing anything as to the record of my own observations, and three by Mr. Plassman, who has kindly sent them to me. These epochs determined by other astronomers were very welcome, as they show that my observations do not essentially differ from theirs.

To pass now to the correction of the elements, I have reduced all the observations, known to me, to the sun and to Greenwich mean time; and have compared them with the following approximate elements:

$$1886,\ 343^d.1684 + 1^d.498124\,E \qquad (1)$$

This comparison gave the following differences between observation and calculation:

Epoch	Minimum d	O − C d	Observer
0	343.457	0.011	Chandler
8	355.454	+0.001	"
12	361.445	0.001	"
16	367.420	−0.018	"
22	376.443	−0.011	"
165	590.569	0.086	Sawyer
167	593.590	−0.064	"
169	596.579	0.072	"
173	602.552	−0.092	"
183	617.559	−0.066	"
189	626.559	−0.055	Chandler

Epoch	Minimum	O — C	Observer
	d	d	
205	650.509	0.075	Chandler
207	653.510	—0.069	"
209	656.503	—0.073	"
217	668.482	0.079	"
221	674.179	—0.074	"
390	927.801	+0.061	Chandler
418	969.713	+0.059	"
428	984.737	+0.072	Yendell
440	1002.738	+0.096	"
448	1014.758?	+0.130	"
661	1333.683	—0.015	Chandler
681	1363.638	—0.053	Yendell
687	1372.654	—0.026	"
695	1384.604	—0.065	Chandler
695	1384.647	—0.019	Yendell
697	1387.588	—0.073	Chandler
697	1387.611	—0.050	Yendell
701	1393.596	—0.057	"
709	1405.561	—0.078	"
709	1405.563	—0.076	Chandler
715	1414.570	—0.057	Yendell
715	1414.573	—0.054	Chandler
717	1417.546	—0.077	Yendell
717	1417.543	—0.080	Chandler
725	1429.530	—0.078	Yendell
737	1447.181	—0.104	"
741	1453.452	—0.126	"
936	1745.706	—0.007	Yendell
952	1769.704	+0.020	"
958	1778.674	0.000	"
962	1784.643	—0.022	"
1058	1928.589	+0.115	Dunér
1066	1940.585	+0.116	"
1134	2042.441	+0.099	Dunér
1136	2045.442	+0.104	"
1144	2057.429	+0.106	"
1150	2066.421	+0.109	"
1152	2069.415	+0.107	"
1154	2072.415	+0.110	"
1158	2078.403	+0.106	"
1160	2081.406	+0.113	"
1162	2084.417	+0.128	Dunér
1168	2093.381	+0.107	"
1172	2099.398	+0.128	"
1176	2105.386	+0.123	"
1180	2111.369	+0.113	"
1182	2114.369	+0.118	"
1184	2117.364	+0.113	"
1184	2117.361	+0.113	Nordenmark
1188	2123.333	+0.092	Dunér
1192	2129.369	+0.136	Plassman
1194	2132.354	+0.121	Dunér
1194	2132.370	+0.140	Plassman
1196	2135.369	+0.113	"
1228	2183.266	+0.100	Dunér
1236	2194.285	+0.134	"
1260	2231.230	+0.125	Dunér
1268	2243.237	+0.147	"
1270	2246.235	+0.148	"
1287	2271.519	(—0.036)	Dunér
1293	2280.167	—0.077	"
1297	2286.165	—0.071	"

In the subsequent discussion I have excluded the minimum-epoch 1287, since this is unquestionably erroneous: and the number of the other odd epochs is so small that its use would not be wholly without detrimental effect. This exclusion has no marked influence on the result.

Grouping the differences as indicated by the horizontal lines, I have found the following normal deviations, separating those for the even and for the odd epochs.

I. FROM EVEN EPOCHS		II. FROM ODD EPOCHS	
Mean Epoch	O — C	Mean Epoch	O — C
12	—0.009	174	—0.073
404	+0.062	212	—0.074
439	+0.099	676	—0.041
952	—0.002	700	—0.060
1062	+0.116	721	—0.082
1148	+0.107	1295	—0.074
1176	+0.118		
1193	+0.121		
1232	+0.117		
1266	+0.140		

These figures appear to indicate with certainty, that the even epochs deviate on the positive side, and the odd epochs on the negative. I have therefore formed equations of condition, introducing the unknown quantities

x = correction of the principal epoch,
y = correction of the period,
$\pm z$ = constant deviation of the even from the odd minima.

The solution of these equations gave the following values of the unknown quantities:

$$x = -0^d.0255\,, \quad y = +0^d.000047\,, \quad z = +0^d.0714$$

The residuals appear to indicate, even if not with great certainty, that the numerical value of z is not constant, but slowly increasing. I have therefore determined the value of dz, excluding the normal difference for Ep. 952, which is inconsistent with the other observations; and thus find,

$$dz = +0^d.000037$$

According to this investigation the elements of the star's period are,

$$\left.\begin{array}{ll}\text{Even epochs.} & 1886\ \text{Dec.}\ \ 9^d\ 12^h\ 20^m\ 10^s\ \text{Greenw.} + 2^d\ 23^h\ 51^m\ 11^s\left(\frac{E}{2}\right)\\ \text{Odd epochs.} & 1886\ \text{Dec.}\ 10^d\ 20^h\ 52^m\ 18^s\ \text{Greenw.} + 2^d\ 23^h\ 51^m\ 11^s\left(\frac{E-1}{2}\right)\end{array}\right\}\ \text{(II)}$$

Or, if we introduce dz,

$$\left.\begin{array}{ll}\text{Even epochs.} & 1886\ \text{Dec.}\ \ 9^d\ 12^h\ 20^m\ 10^s\ \text{Greenw.} + 2^d\ 23^h\ 51^m\ 11^s\left(\frac{E}{2}\right) + 2^s.2(E-792)\\ \text{Odd epochs.} & 1886\ \text{Dec.}\ 10^d\ 20^h\ 52^m\ 18^s\ \text{Greenw.} + 2^d\ 23^h\ 51^m\ 11^s\left(\frac{E-1}{2}\right) - 2^s.2(E-792)\end{array}\right\}\ \text{(III)}$$

The elements II and III leave the following deviations in the normal minima,

Epoch	II	III
	d	d
12	—0.055	—0.027
174	+0.016	—0.007
212	+0.017	—0.019
404	—0.003	+0.012
439	+0.033	+0.016
676	+0.024	+0.020
700	+0.004	+0.001
724	—0.019	—0.021
952	—0.092	—0.098
1062	+0.020	+0.010
1148	+0.007	—0.006
1176	+0.017	+0.003
1193	+0.022	+0.008
1232	+0.011	—0.003
1266	+0.035	+0.017
1295	—0.037	—0.019

The squares of the sums of these errors (always excluding Ep. 952) are,

Using Formula II, 0d.009513 ; Formula III, 0d.005109

We now proceed to the discussion of the above results.

We see in the first place that the constancy of the deviations, from Ep. 1058 to Ep. 1270, inclusive, and next, that the sudden transition from the considerable positive deviations of these epochs, by Formula I, to the also considerable negative deviations of the minima in March and April, 1892, exclude the possibility of representing the differences by a periodical function, as Mr. Yendell has previously endeavored to do. If we therefore adhere to the assumption of a systematic difference between the even and odd epochs, it is manifest that it would be scarcely possible to explain these differences otherwise than by the supposition that the star *Y Cygni* consists of two equally large and bright components, which revolve around their common center of gravity in an elliptic orbit, with a period of revolution of 2d 23h 51m 11s. The perihelion passages occur between the even and the odd epochs. I have already indicated, in a letter to Dr. Scheiner (*A.N.* 3082, p. 159) that such an arrangement in stars of the *Algol*-type suffices to explain the variability, on the supposition (which corresponds to the fact in the case of *Y Cygni*), that the amplitude of the variation amounts at most to 0m.8. I remark further that the eccentricity of the requisite orbit is but moderate. A value of 0.1 would be more than enough to explain the observations yet made. Should the variability of z, at present only suspected, be in future demonstrated as real, this fact could also be very easily explained. It would be required only to suppose a third body, dark or only slightly luminous, which should cause a perturbation in the position of the line of apsides, such as we recognize in the planets and satellites of our solar system.

In order to adduce whatever tends to contradict the above assumption as to the constitution of *Y Cygni*, I must again mention the normal observation Ep. 952. This depends upon four observations of Mr. Yendell, all of them apparently trustworthy. I must admit that the discordance of these observations of Mr. Yendell is inexplicable to me, and makes the correctness, or rather the completeness, of the above explanation of the anomalies in the variations of *Y Cygni*, still somewhat doubtful. But I cannot omit to mention also a fact which supports it. On the evening of Oct. 31, *Y Cygni* when first seen was faint. When it became sufficiently dark, the star appeared but little brighter than at minimum; but it was already rapidly increasing, and it is therefore not possible to deduce a sharp minimum-epoch from my estimates. The observations obtained show, nevertheless, that the minimum occurred at about 1h 19m [illegible] M.T., certainly not later than 1h 34m. Yet the possibility that it had already occurred at 1h 5m, is by no means excluded. Adopting 1h 19m, we have, in heliocentric Greenwich M.T.,

Ep. 949. Min. 1765d.133

Formula III gives, for Ep. 949, the minimum at 1765d.128, thus agreeing almost exactly with the above value, while differing greatly from that deduced by Mr. Yendell from contemporary even epochs, and from all even epochs, on the negative side, and from the normal minimum by [illegible], and also *on the negative side*.

This also shows with great certainty that there then existed a considerable difference between the even and odd epochs. The accurate agreement of my observations with elements III is also certainly worthy of attention.

Taking everything into account, I cannot doubt that the explanation above given of the anomalies in the light-variation of *Y Cygni* is, in the main, correct. By [illegible]

has become much more interesting, especially in case the variability of the quantity z should be confirmed. It would then be possible to determine by photometric observations, not merely the true form of the orbits described by the components, but also the amount of a perturbation.

It is therefore to be hoped that European astronomers will devote somewhat more attention to this star, in the present year, than they have done hitherto. All observations of the variable stars become impracticable here by the middle of May, and it will not be possible to observe *Y Cygni* again until the late months of the autumn. To facilitate observation, I give the following ephemeris, deduced from Formula III, and expressed in Greenwich mean time. I remark, furthermore, that according to the latest observations obtained here, it is probable that the minima will occur about half an hour earlier.

Upsala, 1892 April 9.

Epoch	Minimum			
		d		
1301	1892 April	10	11	20
1321	May	10	10	26
1341	June	9	9	33
1361	July	9	8	40
1381	August	8	7	46
1401	September	7	6	52
1421	October	7	5	58
1441	November	6	5	5
1461	December	6	4	12

Since finishing the preceding computations I have observed still another epoch of minimum; namely,

$$1892 \text{ April } 7^d\ 12^h\ 3^m.2 \text{ Upsala M.T.} \qquad O-C = -0^d.026$$

which accords well with the other epochs observed this year. This minimum appears to be the best of all those determined this year.

NOTES ON DOUBLE STARS (I).

BY A. HALL.

In closing my observations of double stars at the Naval Observatory, it was my intention to make computations on the motions of some of the more interesting pairs, but during the last year other matters prevented this being done. I now undertake to carry out this purpose, and begin with stars that have slow motions, and those whose binary character is becoming apparent from the observations. Some of these stars, like Σ 1126, and others, have extremely slow motions and need no computation, but deserve the attention of observers occasionally, especially if the distance is diminishing so that the angular motion may become rapid in a few years.

Since, in the case of slowly moving stars, means with respect to the time may be taken, in order to represent these motions, I have formed what may be called normal positions in angle and distance, always beginning when possible with the observations of W. Struve, whose work marks an epoch in this branch of stellar astronomy. The rectangular coordinates corresponding to these normals were then computed, and a rectilinear motion of the stars was assumed, given by the equations,

$$x = A + Bt \qquad\qquad y = A' + B't$$

If these expressions satisfy the observations, the stars are probably optically double. But generally this assumption is not sufficient, and it is necessary to introduce the second power of the time, so that the values of the coordinates are of the form,

$$\begin{aligned} x &= A + Bt + Ct^2 \\ y &= A' + B't + C't^2 \end{aligned}$$

If from these equations we eliminate the time, we get the general equation of a parabola, and this assumption shows only the curvature of the apparent path, or its departure from a right line. Assuming the common law of gravitation between the stars, the real curve of motion may be found by the usual method of substituting in the general equation of the second degree the observed values of the coordinates, and then finding, by the method of least squares, the values of the five constants of that equation; from which the conic section will follow. But this method is laborious, and hardly worth undertaking until a large part of the orbit has been described. In this kind of work the errors of observation bear such a great ratio to the quantities measured that a graphical method is generally useful and well worth trying.

In the following computations the angles are reduced to 1860, which is taken as the epoch. The preliminary trials and formulas are omitted, and only the observed quantities and the final results are given. The first of the observed positions are nearly always taken from W. Struve, and the last depend on my own observations. The intermediate positions are generally taken from O. Struve, Dembowski, Dunér and Dawes.

36 *Andromedae* = Σ 73.

The binary character of this star was pointed out by W. Struve, but the motion is very slow. The final equations for the coordinates are

$$\begin{aligned} s \sin p &= -0''.391 + (0''.0157)[t-1860.0] \\ &\qquad + (0''.000177)[t-1860.0]^2 \\ s \cos p &= +1''.211 + (0''.0117)[t-1860.0] \\ &\qquad - (0''.000449)[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C — O	
					Δx	Δy
1832.14	307.83	0.847	—0.669	+0.519	—0.022	+0.017
1847.53	329.61	1.195	0.605	1.031	+0.016	—0.036
1851.50	337.33	1.243	0.479	1.147	+0.007	—0.011
1867.15	349.10	1.235	0.234	1.213	—0.036	+0.059
1875.66	355.93	1.305	—0.093	1.302	—0.009	—0.018
1888.41	8.75	1.201	+0.183	+1.187	+0.015	—0.006

An ephemeris, computed from the above equations, indicates that the distance is diminishing, and we may soon expect a greater motion in angle.

α Piscium = Σ 202.

This star was observed by W. Herschel in 1780, and its motion has given computers some trouble. I find that the observations since 1830 can be well represented by a right line.

$$s \sin p = -1''.750 - (0''.0083)[t-1860.0]$$
$$s \cos p = +2''.784 - (0''.0180)[t-1860.0]$$

Date	p	s	x	y	C — O	
	°	"	"	"	Δx "	Δy "
1831.16	335.80	3.636	—1.490	+3.316	—0.021	—0.013
1841.70	332.50	3.585	1.655	3.180	+0.057	—0.067
1853.46	328.27	3.405	1.791	2.896	+0.095	+0.006
1862.56	327.10	3.345	1.817	2.809	+0.046	—0.071
1872.08	325.02	3.035	1.739	2.488	—0.111	+0.079
1887.49	320.00	2.968	—1.905	+2.276	—0.073	+0.013

Σ 228.

Within recent years the motion of this star has increased, and about one-half of the apparent ellipse has now been described. After a few years, therefore, an orbit may be computed, and the period will probably not much exceed 100 years. In the following table the last five positions depend on my observations; and as they show a great motion in angle, I hope other observers will continue the measures. The parabolic formulas for the apparent motion are,

$$s \sin p = -0''.919 + (0''.02110)[t-1860.0] + (0''.000586)[t-1860.0]^2$$
$$s \cos p = +0''.299 + (0''.00781)[t-1860.0] - (0''.000230)[t-1860.0]^2$$

Date	p	s	x	y	C — O	
		"	"		Δx	Δy
1831.46	262.26	1.080	—1.070	—0.145	+0.026	+0.034
1845.15	275.68	0.960	0.955	+0.095	—0.048	+0.037
1857.20	281.08	0.963	0.934	0.234	—0.010	+0.011
1866.07	291.57	0.950	0.883	0.349	+0.114	—0.011
1869.48	299.48	0.715	0.622	0.352	0.011	0.000
1875.05	310.32	0.625	0.477	0.404	—0.091	0.039
1877.12	313.51	0.540	0.392	0.372	+0.006	—0.006
1881.96	336.16	0.410	—0.166	0.375	—0.007	—0.015
1889.00	26.70	0.434	+0.195	0.388	—0.009	—0.056
1889.98	41.43	0.430	0.285	0.322	—0.011	+0.004
1890.91	51.17	0.330	+0.257	+0.207	+0.038	+0.114

Castor = Σ 1110.

This star is one of the most noted of the double stars, and one of those which turned W. Herschel's attention to the theory of their motions. Bradley's position of 1719 may be used, and compared with recent observations gives 120° of apparent motion in angle. Still the computed orbits have been of the most discordant kind, ranging from the ellipse of J. Herschel, which puts the stars in periastron in 1856, at a distance of 0".7, to the hyperbolas of J. M. Wilson, with eccentricities from 1.6 to 3.2. The recent calculations of Thiele and Doberck give an ellipse with eccentricity of 0.3, and a period of 1000 years. Probably these results are more nearly correct. In this case both components are bright, and this condition has apparently introduced large personal errors into the measurements. Since the time of W. Struve the observations can be represented by the following formulas:

$$s \sin p = -4''.794 - (0''.0008)[t-1860.0] + (0''.0003685)[t-1860.0]^2$$
$$s \cos p = -2''.413 - (0''.0491)[t-1860.0] + (0''.0001785)[t-1860.0]^2$$

Date	p	s	x	y	C — O	
					Δx	Δy
1826.22	262.75	4.404	—4.369	—0.556	+0.022	+0.016
1832.08	258.82	4.494	4.409	0.871	—0.076	—0.024
1840.89	253.41	4.895	4.691	1.398	+0.047	—0.006
1847.60	249.86	5.035	4.727	1.731	0.000	—0.039
1852.95	246.16	5.320	4.866	2.150	+0.096	+0.094
1863.03	241.72	5.369	4.728	2.541	—0.065	—0.017
1871.27	238.66	5.463	4.666	2.841	—0.090	0.106
1878.77	234.11	5.749	4.657	3.370	—0.022	+0.093
1884.30	233.36	5.905	4.744	3.528	+0.119	+0.020
1890.74	229.77	5.783	—4.415	—3.735	—0.056	—0.028

ζ Cancri = Σ 1196.

This multiple star forms a remarkable system. The three stars are of nearly equal brightness. *A* and *B* revolve around each other in 62 years. The star *C* has a slow retrograde motion, but this motion is not uniform. It halts, and even becomes direct for a few years, and then again resumes its retrograde course. To account for this anomaly O. Struve proposed the theory of a dark body near *C*; this star and the dark body revolving around their center of gravity in 18 years. Professor Seeliger has made an elaborate investigation of this problem of four bodies, and finds the theory of Struve confirmed. My observations extend from 1878 to 1891, and I have compared them with Seeliger's theory. The observations of *C* are referred to the mean of *A* and *B*, and when we consider the difficulty of such measurements, and the opportunity for personal errors, the theory is satisfactory. This star is well worth the attention of observers.

Date	*A* and *B*				$\frac{AB}{2}$ and *C*			
	p	*s*	*C* — *O*		*p*	*s*	*C* — *O*	
			Δ*p*	Δ*s*			Δ*p*	Δ*s*
		″		″		″		″
1878.32	102.30	0.813	+1.47	—0.093	130.43	5.363	+1.16	+0.100
1880.21	85.20	0.611	+2.20	+0.161	131.94	5.190	+0.01	—0.138
1881.30	79.00	0.710	+1.57	+0.101	131.03	5.533	+0.70	—0.101
1882.20	73.35	0.792	+1.95	+0.013	131.52	5.612	—0.24	—0.118
1883.31	66.38	0.825	+2.85	+0.010	129.70	5.592	+0.75	—0.025
1884.27	64.16	0.882	—0.16	+0.008	126.08	5.650	+3.41	—0.032
1886.28	51.98	1.030	—0.17	—0.095	125.75	5.625	+1.48	+0.012
1887.21	50.38	0.895	+0.21	+0.060	126.45	5.620	—0.37	+0.015
1888.25	46.55	1.028	—0.18	—0.053	123.62	5.515	+1.29	+0.099
1889.23	43.60	0.986	—1.16	+0.006	123.10	5.705	+0.39	—0.091
1890.28	36.88	0.995	+1.53	+0.014	123.00	5.457	—0.37	+0.103
1891.22	35.68	1.012	—0.70	—0.019	122.36	5.501	—0.70	+0.004

1892 *March* 25.

THE RUTHERFURD PHOTOGRAPHIC MEASURES OF THE STARS ABOUT β CYGNI.

BY HAROLD JACOBY.

The following table contains a list of the stars surrounding β *Cygni*, as determined from a discussion of Mr. Rutherfurd's photographic measures. Considerable time must elapse before this discussion can be published, and it has therefore appeared desirable to communicate the present catalogue without delay. The measures were all made under Mr. Rutherfurd's direction, with his improved machine, provided with a scale for measuring the distances. Six plates were taken, with two exposures on each plate. The dates were 1875 July 26 for three plates, and 1875 Sept. 20 for the other three. The scale-value employed has been derived from a careful comparison of Mr. Rutherfurd's *Pleiades*-measures, with places interpolated from the Yale and Königsberg heliometer determinations. Ten *Pleiades*-plates taken between 1872 Jan. and 1874 Nov. were used for this purpose, and if we consider the scale value as constant, then ten plates give

1 division of scale = 28″.0121 ±0″.00071.

This probable error corresponds to 0″.025 per 1000″. The details of this scale-value determination form part of a paper on the *Pleiades* which is now in press, and will soon be published by the New York Academy of Sciences. The same paper will furnish the data necessary to form an opinion as to the accuracy of Mr. Rutherfurd's later determinations; here it is only necessary to say that the coordinates of the following table possess an average reliability within about 0″.2. It is therefore to be hoped that some of the observatories having the necessary appliances will photograph and measure these stars again during the next few years.

In the table I have adopted for β *Cygni* (no. 19) the place given by Auwers in the *Fundamental-Catalog*. The precessions and secular variations depend upon the constants of Struve, and were computed with the aid of Folie's tables. The magnitudes are Argelander's, and the last column gives the corresponding number in his *Durchmusterung*.

Several stars occur on the plates that are not in Argelander, and several of Argelander's stars are lacking on the plates. Some photographs of the region were accordingly made by Mr. Monell and myself at Columbia College Observatory 1892 April 19. The negatives show all the Rutherfurd stars, as well as the missing ones of Argelander. The latter are:

DM.	magnitude
+27° 3395	8.8
+27 3411	9.0
+27 3417	9.0

The Rutherfurd stars not in Argelander are numbers 28, 32, 33 and 11. It will be noticed that star 28 forms a double with star 27. These two stars are plainly separated on the Rutherfurd plates, while, on the Columbia College plate of 1892 April 19, No. 28 appears only as a slight elongation of No. 27. These stars may therefore constitute a binary system, and they are recommended to the notice of double-star observers.

CATALOGUE OF STARS SURROUNDING β Cygni.

No.	Mag.	Right-Ascension 1875.0	Prec.	Sec. Var.	Declination 1875.0	Prec.	Sec. Var.	D.M.
		° ′ ″	″		° ′ ″	″		
1	9.3	290 28 23.04	+36.1325	+0.0161	27 54 51.57	+7.0143	+0.3262	27 [illegible]
2	9.3	290 30 33.26	+36.2116	+0.0159	27 42 6.02	+7.0262	+0.3263	27 [illegible]
3	9.0	290 42 12.43	+36.0412	+0.0162	28 9 42.42	+7.0847	+0.3248	28 [illegible]
4	9.2	290 43 20.20	+35.9285	+0.0162	28 25 53.75	+7.0960	+0.3237	28 3345
5	9.0	290 46 39.52	+35.9031	+0.0165	28 30 1.55	+7.1140	+0.3232	28 3347
6	8.2	290 48 2.98	+36.2550	+0.0157	27 40 1.45	+7.1217	+0.3265	27 3397
7	9.2	290 49 36.53	+36.4228	+0.0156	27 16 2.71	+7.1301	+0.3279	27 3398
8	8.8	290 51 54.94	+36.4904	+0.0153	27 6 34.88	+7.1428	+0.3285	27 3400
9	8.7	290 53 24.57	+36.0247	+0.0162	28 13 49.69	+7.1508	+0.3241	28 3352
10	8.8	290 55 50.39	+35.8805	+0.0163	28 34 41.97	+7.1642	+0.3227	28 3353
11	8.0	291 0 58.78	+36.2668	+0.0159	27 40 21.12	+7.1921	+0.3261	27 3401
12	9.0	291 4 40.48	+36.4077	+0.0156	27 20 34.31	+7.2123	+0.3272	27 3405
13	9.3	291 5 1.25	+36.2142	+0.0160	27 48 33.87	+7.2141	+0.3255	27 3406
14	9.0	291 10 7.74	+36.5116	+0.0154	27 6 20.83	+7.2419	+0.3279	27 3407
15	8.2	291 13 58.87	+35.9487	+0.0163	28 27 57.49	+7.2629	+0.3228	28 3363
16	8.6	291 21 57.90	+36.5759	+0.0151	26 58 49.10	+7.3064	+0.3280	26 3570
17	8.9	291 23 6.29	+36.1464	+0.0160	28 1 12.20	+7.3125	+0.3241	27 3409
18	9.1	291 23 50.36	+36.1229	+0.0162	28 4 12.32	+7.3165	+0.3238	28 3366
19	3.0	291 25 12.66	+36.2829	+0.0157	27 41 53.93	+7.3258	+0.3252	27 3410
20	6.5	291 25 44.60	+36.2843	+0.0157	27 42 13.81	+7.3268	+0.3252	27 3411
21	8.9	291 27 9.07	+36.4367	+0.0154	27 19 56.62	+7.3344	+0.3266	27 3412
22	8.9	291 27 21.94	+36.0428	+0.0163	28 16 44.77	+7.3359	+0.3230	28 3367
23	8.7	291 31 26.15	+36.5475	+0.0155	27 4 28.97	+7.3577	+0.3273	27 3413
24	8.9	291 32 19.50	+36.2947	+0.0159	27 41 20.35	+7.3626	+0.3251	27 3415
25	8.8	291 33 30.25	+36.0760	+0.0162	28 12 59.43	+7.3689	+0.3231	28 3370
26	8.2	291 37 26.97	+35.9812	+0.0163	28 27 11.63	+7.3903	+0.3221	28 3373
27	8.0	291 46 1.18	+36.1803	+0.0160	28 0 6.18	+7.4371	+0.3236	27 3421
28	. .	291 46 1.40	+36.1797	+0.0160	28 0 11.50	+7.4371	+0.3235	
29	8.8	291 49 15.53	+36.4711	+0.0155	27 18 30.22	+7.4543	+0.3260	27 3423
30	8.7	291 50 18.56	+36.3286	+0.0155	27 39 23.09	+7.4600	+0.3248	27 3425
31	8.7	291 51 30.15	+36.5356	+0.0151	27 9 27.12	+7.4665	+0.3264	27 3426
32	. .	292 0 46.36	+36.4560	+0.0155	27 22 35.81	+7.5166	+0.3254	
33	. .	292 1 8.43	+36.0943	+0.0161	28 14 58.64	+7.5187	+0.3222	
34	8.8	292 1 43.42	+35.9585	+0.0163	28 34 29.88	+7.5218	+0.3208	28 3378
35	8.4	292 1 45.49	+36.5623	+0.0151	27 7 13.82	+7.5219	+0.3263	27 3428
36	8.9	292 2 6.81	+36.0929	+0.0161	28 15 21.05	+7.5239	+0.3221	28 3379
37	9.0	292 3 11.44	+36.4997	+0.0153	27 16 38.28	+7.5300	+0.3257	27 3429
38	8.5	292 3 50.14	+36.4206	+0.0154	27 28 16.18	+7.5333	+0.3249	27 3430
39	9.4	292 7 15.93	+36.1169	+0.0161	28 12 50.91	+7.5544	+0.3220	28 3382
40	9.5	292 13 35.34	+36.2060	+0.0159	28 1 0.80	+7.5860	+0.3226	27 3433
41	. .	292 16 4.34	+36.2525	+0.0159	27 54 12.64	+7.5993	+0.3228	
42	8.4	292 17 30.60	+36.1574	+0.0161	28 8 10.88	+7.6070	+0.3220	28 3392

Columbia College, New York, 1892 *April* 25.

THE FAINTER VARIABLES.

BY S. D. TOWNLEY.

In no. 183 of the *Astronomical Journal*, Mr. CHANDLER published a list of variable stars having faint minima, and urgently asked that some of the large refractors might be used to follow these stars in their fainter phases. In the next number of the Journal, Mr. PARKHURST published some notes regarding the minima of a part of these stars, as seen

with his telescope of 9 inches aperture. During the past three years I have followed a few of these variables with the 15½-inch equatorial of the Washburn Observatory. Some of them become invisible with this telescope, which lends evidence to the belief that perhaps a few variables send us absolutely no light at minimum. It would be interesting if photography, with a telescope like the giant refractor of Mt. Hamilton, could be used to follow some of these specks of light, and thus help to ferret out the mysteries of these most peculiar of peculiar phenomena.

If any one with a larger telescope than that of the Washburn Observatory undertakes to do such work as this, the following notes may be of service in choosing those stars which it is most desirable to have observed with a large instrument. The numbers of the stars below are the CHANDLER catalogue-numbers (*A.J.*, nos. 179, 180). The magnitudes given are fixed upon the assumption that the *minimum visibile* of this telescope is $14^{M}.7$.

111. One minimum $13^{M}.3$; another $13^{M}.6$.
243. Invisible for nearly two months.
431. Invisible for two months or more.
466. Have several minima at $14^{M}.5$.
513. One minimum $14^{M}.0$; in another the star was invisible for six weeks.
1222. One minimum $12^{M}.8$.
1717. " " $13^{M}.5$.
1761. " " $14^{M}.2$.
1911. Light changes irregular; possibly short-term period. One minimum $11^{M}.5$. This star needs particular attention.
2178. One minimum about $11^{M}.0$.
2528. " " $12^{M}.5$.
2742. " " $14^{M}.5$.
5130. Invisible for several weeks.
5138. Does not disappear.
5583. Minimum about $14^{M}.0$.
5795. Invisible for two months.
6905. One minimum $12^{M}.5$.
6921. Minimum less than $14^{M}.5$.
7220. Invisible for two months or more.
7252. Minimum less than $14^{M}.5$.
7577. Invisible for one month or more.
7659. One minimum $13^{M}.5$.

Madison, Wis., 1892 *April* 19.

NOTE ON PUBLISHED MAXIMA AND MINIMA OF *Y OPHIUCHI*.

BY PAUL S. YENDELL.

The writer desires to state that the residuals for this star, Vol. X, p. 99, are incorrect, and should read as follows:

E	O — C for Maxima
	d
164	—1.08
166	—0.34
167	—1.68
168	—0.82
173	—0.97

E	O — C for Minima
	d
167	—1.23
168	—0.87
169	+2.99
170	—0.75
171	—2.59

The comparisons are with the elements in CHANDLER'S Catalogue.

Dorchester, Mass., 1892 *April* 16.

CORRIGENDA.

Page 93, line 26 *for* 20^{h} 28^{m} $23^{s}.7$ *put* 20^{h} 48^{m} $23^{s}.7$
Page 141, col. 1, line 33 *for* 22 28 35 *put* 22 28 3.5
Page 180, col. 1, *θ Herculis* Sept. 6.3 Obs. δ insert 23″.82
Page 181, col. 1, *α Lyrae* Apr. 11.7 Obs. δ *for* 26″.87 *put* 26″.57
Page 181, col. 2, 40 *Cygni* Oct. 15.3 Obs. δ *for* 58″.34 *put* 58″.44
Page 181, col. 2, 10 *Lacertae* Dec. 3.2 Obs. δ *for* 26′ *put* 27′
Page 182, col. 1, 10 *Lacertae* Obs. δ *for* 26′ *put* 27′
Page 182, col. 2, 32 *Androm.* Nov. 16.4 Obs. δ *for* 29″.46 *put* 29″.66
Vol. VIII, p. 12, col. 1, the probable errors of *x, y, z* for 1865, are given ten times too large.

CONTENTS.

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THE
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SOLUTION OF STRUVE'S EQUATIONS FOR THE DETERMINATION OF THE ABERRATION, TAKING INTO ACCOUNT THE POSSIBLE VARIABILITY OF THE LATITUDE.

BY B. M. ROSZEL AND B. S. ANNIS, STUDENTS IN ASTRONOMY, JOHNS HOPKINS UNIVERSITY.

During the years 1840 to 1842 STRUVE derived the constant of aberration from observations in the prime-vertical of Pulkowa. For this purpose he formed 298 equations of condition between the observed and computed declinations of seven stars; β and δ *Cassiopeae*, o *Ursae Majoris*, ι, o, and 39 b *Draconis*, and P. *XIX*. 371. His equations of condition were of the general form:

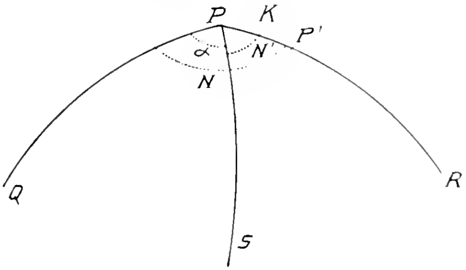
$$x + ay + bp + c\mu + ir = n,$$

where x = correction to the mean declination of the star:
y = correction to the constant of aberration (20″.50);
p = star's annual parallax:
μ = star's proper motion in declination;
r = correction to the constant of nutation;
n = difference between the observed and computed declinations.

The coefficients a, b and c, were all computed and tabulated by STRUVE. He omitted ir, as being insensible.

The original reductions were made by STRUVE on the supposition that the latitude of Pulkowa was constant (= 59° 46′ 18″.00). Assuming it to vary, and adopting Dr. CHANDLER's period of 427 days, the position of the axis of rotation of the earth can be determined from these equations by the following method, as indicated by Prof. NEWCOMB in his lectures and carried out by us.

For this purpose two additional unknown quantities, which we may call z and u are introduced. The following figure will show their significance:



Let P be the position of the pole of the axis of figure:
P' " position of the pole of the axis of rotation at any instant:
PS " meridian of Pulkowa:
N' " E. longitude of PR (the meridian of P') from PS:
PQ " position of the meridian PR on 1840 Apr. 0;
N " E. longitude of PR from PQ:
α " W. longitude of PQ from PS;
K " distance PP'.

$$\begin{aligned}\text{Then } d\varphi &= K\cos N' \\ &= K\cos(N-\alpha) \\ &= K\cos\alpha\cos N + K\sin\alpha\sin N.\end{aligned}$$

And we define z and u by the equations:

$$z = K\cos\alpha \qquad K = \sqrt{z^2+u^2}$$
$$u = K\sin\alpha \qquad \tan\alpha = \frac{u}{z}$$

It will be seen that the figure refers to the poles on the surface of the earth. The pole of figure is in constant relation to places on the earth's crust, hence it is taken as stationary, and the pole of rotation considered to revolve about it, although the reverse is presumably the case.

The angle N increases uniformly at the rate of 360° in 427 days, and its value for any date can be immediately computed, assuming it to start from zero on 1840 April 0, about the time STRUVE began his observations.

Thus, it will be seen that z and u will determine the position of the pole of the axis of rotation on 1840 April 0.

The coefficients of z and u were computed for the whole series of observations. Retaining STRUVE's x and y, but omitting p, μ and r, since these equations will not determine them, and introducing z and u our equation of condition now becomes

$$x + ay + z\cos N + u\sin N = n.$$

In this manner equations of condition were formed

In order to lessen the labor of solution, the equations were divided into groups, taking the mean of the equations formed from observations near each other in time to correspond to their mean date. All observations made near noon were considered untrustworthy, the unequal heating of the shutters of the observatory by the sun producing lateral refraction, and were omitted. By this grouping and the omission of the observations made near noon, STRUVE's 298 equations were reduced to 101.

The observations were all given unit-weight unless marked with an asterisk in the original paper, in which case their weight was taken to be 0.5. The reason for this is that STRUVE considered the observations so recorded to be less exact than the rest.

Having formed the group-equation, a weight was given to it, in every case, equal to the sum of the weights of the separate equations forming the group. The normal equations formed for each star separately are:

β Cassiopeae.

$$\begin{aligned} 29.00x_1 + 1.03y + 3.20z + 5.02u &= -19.30 \\ 1.03x_1 + 16.91y - 14.31z + 8.53u &= -\ 1.63 \\ 3.20x_1 - 11.31y + 17.45z - 2.07u &= -\ 1.87 \\ 5.02x_1 + 8.53y - 2.07z + 11.56u &= -\ 1.30 \end{aligned}$$

δ Cassiopeae.

$$\begin{aligned} 36.00x_2 + 2.97y - 0.68z + 1.76u &= -6.36 \\ 2.97x_2 + 14.58y - 13.75z + 1.68u &= -0.21 \\ -0.68x_2 - 13.75y + 18.01z + 2.33u &= -1.58 \\ 1.76x_2 + 1.68y + 2.33z + 18.00u &= -3.10 \end{aligned}$$

υ Ursae Majoris.

$$\begin{aligned} 72.50x_3 + 18.08y + 15.56z - 2.79u &= +34.05 \\ 18.08x_3 + 28.81y + 31.59z - 12.48u &= +\ 7.55 \\ 15.56x_3 + 31.59y + 43.51z - 8.16u &= +\ 6.42 \\ -2.79x_3 - 12.48y - 8.16z + 28.80u &= -\ 0.97 \end{aligned}$$

ι Draconis.

$$\begin{aligned} 54.00x_4 + 22.73y + 12.47z + 10.55u &= +1.53 \\ 22.73x_4 + 36.66y + 9.46z + 29.35u &= +0.26 \\ 12.47x_4 + 9.46y + 20.50z - 1.45u &= -1.34 \\ 10.55x_4 + 29.35y - 1.15z + 33.52u &= -0.07 \end{aligned}$$

39 b Draconis.

$$\begin{aligned} 24.00x_5 + 13.12y - 9.89z + 9.64u &= +3.12 \\ 13.12x_5 + 20.75y - 12.41z + 16.09u &= +1.92 \\ -9.89x_5 - 12.41y + 10.22z - 8.18u &= -2.04 \\ 9.64x_5 + 16.09y - 8.18z + 13.79u &= +1.06 \end{aligned}$$

ο Draconis.

$$\begin{aligned} 11.00x_6 + 4.09y - 4.83z + 1.66u &= +11.76 \\ 4.09x_6 + 28.18y - 8.10z + 22.86u &= -\ 1.18 \\ -4.83x_6 - 8.10y + 19.08z - 1.05u &= -\ 2.48 \\ 1.66x_6 + 22.86y - 1.05z + 21.91u &= -\ 2.35 \end{aligned}$$

P. *XIX* 371.

$$\begin{aligned} 11.00x_7 + 1.91y - 1.01z - 0.25u &= -1.77 \\ 1.91x_7 + 12.82y - 3.88z + 9.63u &= -1.53 \\ -1.01x_7 - 3.88y + 5.20z - 1.08u &= +0.25 \\ -0.25x_7 + 9.63y - 1.08z + 8.81u &= -1.21 \end{aligned}$$

x, being the correction to the mean declination, varies from star to star, while the remaining unknowns are the same for all. Consequently, after the elimination of the x's, the resulting normal equations in y, z and u, respectively, were added, and the values of these quantities determined in the usual way.

These values substituted in the several normals in x, gave the x's.

The weights and probable errors of y, z and u were obtained in the ordinary manner. The weight of any x was taken to be its coefficient in its normal equation, and then its probable error was obtained from the residuals of all seven stars. The solution gives the following values for the unknown quantities:

		Struve's Value
β Cassiopeae.	$x = -0''.651 \pm 0.0240$	$-0''.609 \pm 0.0271$
δ "	$x = -0.173 \pm 0.0216$	-0.128 ± 0.0322
υ Ursae Maj..	$x = +0.481 \pm 0.0152$	$+0.477 \pm 0.0152$
ι Draconis,	$x = +0.054 \pm 0.0176$	$+0.044 \pm 0.0279$
39 *b* "	$x = +0.099 \pm 0.0264$	$+0.140 \pm 0.0333$
ο "	$x = +0.360 \pm 0.0202$	$+0.369 \pm 0.0198$
P. *XIX*. 371.	$x = -0.128 \pm 0.0346$	-0.110 ± 0.0317

$$\begin{aligned} y &= -0''.0157 \pm 0.0130 \\ z &= -0.0320 \pm 0.0118 \\ u &= -0.0604 \pm 0.0134 \end{aligned}$$

Const. of aberr. = 20″.4813 STRUVE's value = 20″.4451

The corrections to the mean declinations, together with their probable errors, agree very closely with the original values derived by STRUVE. The correction to the constant of aberration does not agree so well with that obtained by him. The reason for this discrepancy is, principally, the assumption of a variation in the latitude. The omission of twenty-one of STRUVE's observations made near noon would have an effect upon the y.

The large probable errors of single declinations obtained by STRUVE for β and δ *Cassiopeae* led him to give smaller weights to the observations of these two stars than to those of the other five, while in this solution a single observation of any star was given equal weight with that of any other. This would also change the value of y to some extent.

We also made a second solution of the normal equations in y, z and u, giving to observations on β and δ *Cassiopeae* the weights 0.7 and 0.5 respectively. The normals in each case are:

1st Solution.

$$\begin{aligned} +136.53y - 14.56z + 69.19u &= -5.83 \\ -14.56y + 122.66z - 17.87u &= -2.63 \\ +69.19y - 17.87z + 129.33u &= -8.28 \end{aligned}$$

2d Solution.

$$\begin{aligned} +124.30y - 3.39z + 64.41u &= -5.71 \\ -3.39y + 108.53z - 18.26u &= -4.41 \\ +64.41y - 18.26z + 117.16u &= -6.60 \end{aligned}$$

Which last gives

$$\begin{aligned} y &= -0''.0247 \pm 0''.0118 \\ z &= -0.018 \pm 0.0107 \\ u &= -0.042 \pm 0.0121 \end{aligned}$$

By putting $u = z = o$, in our final normals in y, we should obtain a value for the constant of aberration very close to STRUVE's. The values obtained in these various ways are:

STRUVE's definitive value.		20″.4451
Assuming a variability of the latitude.	1st sol.,	20.4843
" " " "	2d sol.,	20.4753
By putting $u = z = o$, in normal in y.	1st sol.,	20.4573
" " " "	2d sol.,	20.4541

The last value differs from STRUVE's by only 0″.009.

Combining z and u, we obtain for k, the radius of the curve in which the pole P' was supposed to move.

$$k = 0''.068$$

This is much smaller than the value obtained by Dr. CHANDLER, being in fact about two-sevenths of it, and furnishes very inconclusive evidence for assuming a variability of the latitude at the time of these observations.

We append the mean errors of a single observation for the separate stars for our two solutions.

		1st Sol.	2d Sol.
β Cassiopeae,	mean error =	0.2256	0.1887
δ "		0.2798	0.1978
η Ursae Majoris,		0.1977	0.1977
ι Draconis,		0.1849	0.1849
39 *b* "		0.2241	0.2241
ο "		0.1939	0.1939
P. *XIX*. 371.		0.1572	0.1572

ON SOME OBSERVED MINIMA OF *Y CYGNI*.

BY PAUL S. YENDELL.

In the paper published by Prof. DUNÉR in no. 261 of this Journal, detailing his very beautiful explanation of the anomalies in the period of *Y Cygni*, he says, referring to the four observed minima published by me in Vol. X, p. 132, "I must admit that the discordance of these observations of Mr. YENDELL is inexplicable to me, and makes the correctness, or rather, the completeness, of the above explanation of the anomalies in the variation of *Y Cygni* somewhat doubtful."

Concerning the correctness of Prof. DUNÉR's explanation, it seems to me that to any one conversant with the whole body of the evidence in the case, but one opinion is possible: the fact of the persistence of the earliness of the odd minima, and the lateness of the even ones, occurred to me, after closing my observations for the year 1891, as being suggestive of a double period; but none of Prof. DUNÉR's observations later than Ep. 1136 had then come to my knowledge, and the two groups of minima, Ep. 12 and Ep. 952, with the tendency to a sudden increase in the residuals toward the end of three of the six groups of observations, and the apparent indication of a rapid shortening of the period from Ep. 1131 to 1211, were so apparently incompatible with any such assumption that the idea was given up.

The publication of Prof. DUNÉR's group of observations, taken simultaneously with my own series for 1891, puts a very different face on the matter, and appears to me to prove the substantial correctness of his fundamental assumption beyond the possibility of a cavil; and the fact that this group of observations of mine (Ep. 952) seems to be violently discordant with it, renders it, in my opinion, advisable to publish the details of the minima in question, so that an independent judgement of their value may be arrived at, by any one desirous of so doing.

The comparison-stars employed in these observations were CHANDLER's *ι* and *p* [See *A.J.* Vol. VII, p. 47], and one of my own, *h* (= DM. 34 4193, $8^{m}.6$); their light-values, on the scale formed at the end of my last series of observations, from the whole body of material accumulated in four years' observations of the star, with their estimated magnitudes, are as follows:

	Light	Mag.
ι	11.9	7.4
p	6.7	7.9
h	0.0	8.5

The observations in question were made in the open air, with my 4¼-inch Clacey refractor, and a positive eye-piece giving a power of 30.

The system of weights used ranges from 5 to 1, and indicates the gradation between an exceptionally certain observation, and nearly pure guess-work; for a single-star comparison, a higher weight than 3 is never used; applied to the deduced times of minima and maxima, 5 signifies a particularly good determination; 4, good; 3, fair; 2 and 1, doubtful and very doubtful.

The observations in detail are as follows:

Ep. 936 1890 Oct. 11 Boston Mean Time

h m		wt.	L.
9 13	*e* 2 *V*, *V* 2 *p*	4	9.30
58	*V* 0-1 *p*	3	7.20
10 6	*V p*	3	6.70*
33	*p* 1 *V*, *V p*	3	6.20
53	*p* 1-2 *V*, *V* 4 *b*	4	46.0
11 18	*p* 4 *V*, *V* 3 *b*	4	2.85
33	*p* 2 *V*, *V* 2 *b*	4	3.35
48	*p* 2-3 *V*, *V* 1-2 *b*	4	2.85
12 3	*p* 3 *V*, *V* 1-2 *b*	4	2.60
13	*p* 3 *V*, *V* 1-2 *b*	4	2.60
28	*p* 2-3 *V*, *V* 2 *b*	4	3.40
41	*p* 2 *V*, *V* 2 *b*	4	3.35
58	*p* 2 *V*, *V* 2 *b*	4	3.35

Weather clear. * Aperture reduced to 2 in., for this obs. only.

The time of minimum, deduced from the curve plotted from these observations, is 12ʰ 9ᵐ, Boston mean time; by the mean light-curve published in this Journal, Vol. IX p. 167, a minimum is indicated at 11ʰ 58ᵐ.2.

A weight of 4 was assigned to this minimum, as — although owing to the star's low altitude, observations had to be given up very shortly after the phase was certainly passed — the minimum itself was pretty sharply marked, and, it seems probable, is not more than six or seven minutes out of the way.

Ep. 952. 1890 Nov. 4.

h m		wt.	L.
8 59	*e* 2 *V*, *V* 4 *p*	4	9.3
9 50	*e* 3 *V*, *V* 1 *p*	4	9.3
10 16	*V* 0-1 *p*	3	7.2
39	*p* 1 *V*, *V* 5-6 *b*	4	5.6
56	*p* 2 *V*, *V* 4-5 *b*	4	4.6
11 9	*p* 2-3 *V*, *V* 4 *b*	4	4.1
27	*p* 4 *V*, *V* 3 *b*	4	2.85
47	*p* 4-5 *V*, *V* 2-3 *b*	4	2.35
56	" "	4	2.35
12 6	*p* 4 *V*, *V* 3 *b*	4	2.85
14	*p* 4-5 *V*, *V* 2 *b*	4	2.10
24	*p* 5 *V*, *V* 2 *b*	4	1.85
34	*p* 4 *V*, *V* 2 *b*	4	2.35
44	*p* 4 *V*, *V* 3 *b*	4	2.85
54	" "	4	2.85

Clear. Moon rose at 11ʰ

The time of minimum, deduced from the plotted curve, is 12ʰ 23ᵐ, to which a weight of 3 was assigned. The time by mean light-curve is 12ʰ 26ᵐ.

By an error in transcription, the published time of this and the two following minima are 15ᵐ.5 too early, the "Standard sea-coast time" (= Gr. M.T. —5ʰ) being the time which was used for the observations and reduction, and inadvertently copied without modification:

Ep. 958. 1890 Nov. 13.

h m		wt.	L.
9 25	*p* 1 *V*	3	5.70
37	*p* 1-2 *V*, *V* 5-6 *b*	4	5.35
10 5	*p* 2-3 *V*, *V* 4-5 *b*	4	4.35
30	*p* 3 *V*, *V* 4 *b*	4	3.85
11 15	*p* 4 *F*, *V* 3 *b*	4	2.85
29	" "	4	2.85
45	*p* 4 *V*, *V* 2-3 *b*	4	2.60
59	*p* 3 *V*, *V* 4 *b*	4	3.85
12 15	" "	3	3.85*

* Star very low.

The plotted curve shows a minimum at 11ʰ 41ᵐ, to which a weight of 3 was assigned; by the use of the mean curve, a minimum at 11ʰ 12ᵐ is indicated.

Ep. 962, 1890 Nov. 19.

h m		wt.	L.
9 33	*p* 4 *V*, *V* 3 *b*	4	2.85
10 5	*p* 3-4 *V*, *V* 4 *b*	4	3.60
11 0	*p* 5 *V*, *V* 2-3 *b*	4	2.10
15	*p* 4 *V*, *V* 2-3 *b*	4	2.60
25	*p* 4 *V*, *V* 3 *b*	4	2.85
40	" "	4	2.85

Bright moon and star low.

The single curve indicates a minimum at 10ʰ 56ᵐ, but from the undecided character of the deduction, and the unfavorable circumstances under which the observations were made, the nominal weight of 1 only was given it; the mean curve gives a minimum at 11ʰ 12ᵐ.

Ep. 956. Three observations obtained Nov. 10, as follows:

h m		wt.	L.
10 11	*V* 1 *p*	3	7.70
38	*p* 2 *V*, *V* 5 *b*	4	4.85
11 2	*p* 3 *V*, *V* 3 *b*	4	3.35

Clouded over after this observation and no more were obtained.

The mean light-curve indicates a minimum at 11ʰ 45ᵐ, which is given here for what it is worth.

Although from the circumstances of the case, in none of these series could many observations be obtained after the minimum, the minima occurring when the star's altitude was low, this phase was, in all but one case, apparently quite distinctly marked, as the sharp rise of a step or two after the minimum was, as usual with this star, very noticeable in three of the four series. The error detected in the transcription of the times of minima will diminish the residuals, according to Dunér's elements III, by about 13 minutes in the mean, which, however, is not sufficient to affect the apparent discordance materially, it being evident that the difference of $-0^d.098$ is equivalent to nearly the whole interval between the star's normal light and its minimum.

Dorchester, Mass., 1892 *May* 14.

SUPPLEMENT TO THE ARTICLE "ON THE CHIEF CAUSE OF THE ANOMALIES IN THE LIGHT-VARIATIONS OF *Y CYGNI*."

BY N. C. DUNÉR.

In no. 261 of the *Astronomical Journal*, Mr. YENDELL has published a considerable series of observations of *Y Cygni*. The whole of these belong to uneven epochs, while the contemporary European observations, by PLASSMAN, NORDENMARK and myself, belong to even epochs. These simultaneous series are naturally of the greatest importance for deciding the question whether the constant difference which I assumed between the even and the odd epochs actually exists. In fact, a comparison between Mr. YENDELL's observations and the European ones indicates that the uneven epochs have occurred, not 36 hours but only 32 hours, *after*, and consequently 40 hours before, the even epochs. Now my formula, based on the above assumption, requires the intervals which I found. The correctness of my view concerning the nature of the variations in *Y Cygni* seems hereby fully proved, and I have compared the observations of Mr. YENDELL with my last formula for uneven epochs, finding the following differences between observation and computation.

Epoch	O—C d	Epoch	O—C d
1145	+0.050	1195	—0.044
1163	+0.022	1197	—0.039
1165	+0.012	1205	—0.016
1169	+0.010	1211	—0.054
1183	—0.016	1213	—0.056
1189	—0.017	1215	—0.055
1191	—0.041		

or in the mean $-0^{d}.023$.

These deviations manifest a strong, although by no means regular, rate. On the other hand the jump between Epoch 1169 and Epoch 1183 is very considerable, and from that time on, the deviations are almost constant. Now since the European observations show altogether constant deviations, it is highly probable that Mr. YENDELL's method of observation may have changed, for which moreover his observations in the years 1888 and 1889 present counterparts. My observations in 1892 imply that the last nine observations of Mr. YENDELL are the correct ones, and that the first four are in error. A new determination of the value of dz, using both Mr. YENDELL's observations and my last ones, would certainly increase it, and thereby render the deviation of the observations of August and September very considerable. This internal contradiction leads me to feel no farther hesitation relative to the strong discordance of the normal epoch 952. This is founded upon four observations of Mr. YENDELL. But if we constructed a normal epoch from his observations in August and September, 1891, this would differ almost as greatly from his subsequent observations, as the normal minimum-epoch 952 differs from the obervations of other astronomers.

I believe it will be much more correct to attribute the discordance simply to errors of observation, than to anomalies in the light-variation of the star. Indeed it is far from easy, in observations of variable stars, to free one's self completely from previous impressions concerning the rate of the changes in light, and for the *Algol*-stars this difficulty is much greater; since it is impossible to forget the observations which one has already made on the same evening. If, furthermore, the whole amplitude is small, as is the case of *Y Cygni*, and the available comparison-stars are not so convenient as could be wished, the uncertainty must be still greater. I see no way to escape entirely from this influence unless one could either determine the minimum by photography, or — what would perhaps be still better — if both in Europe and America, as many observers as possible would occupy themselves with this star, which does not seem too much to hope, now that it has become particularly interesting. At any rate, the consideration, which has probably been the chief one hitherto in preventing the observations, namely, the impossibility of predicting the minima with sufficient accuracy, will now no longer exist.

Upsala, 1892 *April* 30.

HYPERBOLIC ELEMENTS AND EPHEMERIS OF COMET *a* 1892.

BY REV. G. M. SEARLE.

The ephemeris of this comet published in no. 262 of this Journal indicating, when compared with observation, a hyperbolic correction according to the computation there given, it seemed desirable to compute a new orbit. This, however, was delayed, partly by my absence from this city, and partly by the want of sufficient observations to form a new place. Finally, as an observation which I obtained on the morning of April 23 seemed fairly trustworthy, it was used in want of better material, with two normal places formed for March 10.5 and March 29.5. These gave the following orbit, by which all three places are accurately represented:

$$T = \text{Apr. } 6.6344 \text{ Gr. M.T.}$$

$$\left.\begin{aligned}\omega &= \;\; 24^\circ\ 30'\ 10''\\ \Omega &= 210\ \ 56\ \ 45\\ i &= \;\; 38\ \ 42\ \ 36\end{aligned}\right\}\ 1892.0$$

$$\log q = 0.011702$$

$$\log e = 0.001295$$

The coordinate equations are:

$$x = [9.922902]\sin(v + 319^\circ\ 3'\ 16'')$$

$$y = [9.999778]\sin(v + 257\ \ 51\ \ 29)$$

$$z = [9.738476]\sin(v + 345\ \ 3\ \ 28)$$

The parabolic ephemeris being continued, the following corrections were found to it from the above orbit:

	$\Delta\alpha$	$\Delta\delta$
	s	′ ″
May 6.5	—20.7	—5 6
11.5	—28.3	—5 13
22.5	—36.6	—6 1
30.5	—15.5	—6 12

By a comparison with *μ Pegasi* obtained this morning (May 6) the approximate corrections to the parabolic ephemeris were —19s and —5′.0; it would seem, therefore, that the above hyperbolic orbit is likely to represent observations well for some time, as it needs at present practically no correction.

By applying corrections interpolated from those above, the following ephemeris for Greenwich midnight, and representing the hyperbolic orbit, is obtained:

Gr. M.T.	α	δ	log Δ	Br.
	h m s	° ′		
May 10.5	22 59 45	+26 54.1	0.1211	0.65
11.5	23 2 32	27 30.1		
12.5	5 17	28 5.3	1270	
13.5	8 0	28 39.9		
14.5	10 42	29 13.7	1329	0.58
15.5	13 22	29 46.9		
16.5	16 1	30 19.1	1387	
17.5	23 18 38	+30 51.3		
May 18.5	23 21 11	+31 22.5	0.1444	0.52
19.5	23 18	31 53.1		
20.5	26 20	32 23.2	1499	
21.5	28 50	32 52.7		
22.5	31 19	33 21.6	1553	0.46
23.5	33 47	33 49.8		
24.5	36 13	34 17.4	1606	
25.5	38 37	34 44.6		
26.5	40 59	35 11.3	1657	0.42
27.5	43 19	35 37.4		
28.5	45 38	36 3.0	1707	
29.5	47 55	36 28.1		
May 30.5	23 50 11	+36 52.7	0.1756	0.38

In a letter of May 18, Father Searle states that he has no special confidence in hyperbolic elements for this comet, since, as he has previously remarked, the orbit appears to admit of much more variation than usual, while well representing the geocentric path.

The ephemeris, and indeed the elements themselves, apart from the eccentricity, are in singularly close accordance with those obtained on the assumption of a parabolic orbit by Bidschof at Vienna and Berberich at Berlin [*A.N.* 3087,8]. Yet while the fundamental places are absolutely represented here, there are slight variations of the middle places for these European parabolas, as also for Dr. Hind's (p. 15).

ON THE VARIABILITY OF DM. 33° 470,*

$\alpha = 2^h\,28^m\,15^s.9 \qquad \delta = +33^\circ\,37'.8$ (1855).

BY PAUL S. YENDELL.

This star is noticed by Espin (*Astrom. Nach.*, Vol. CXXVI. p. 79) as "probably variable," having been observed by him as 7M.5, 1890, Nov. 7.

In the same volume, p. 117, Mrs. Fleming announces the star as variable, and gives seven measures from various H.C.O. photographic charts and spectra, from 9M.2 to 6M.8, on dates from 1887 Nov. 7 to 1890 Oct. 17.

The Bonn Observations give it, 1858 Jan. 7, as 9M.2, which is the DM. magnitude.

I have observed the star eighteen times, from 1891 Dec. 5 to 1892 April 13; the original observations are as follows:

	Light	Mag.		Light	Mag.
1891 Dec. 5	5.8	9.9	1892 Mar. 16	36.3	*6.1
1892 Jan. 1	6.3	9.8	19	35.3	6.2
31	22.0	7.9	21	34.8	6.2
Feb. 15	29.0	6.9	24	34.5	6.25
Mar. 4	37.5	5.9 ☽	29	31.0	6.8
5	35.3	6.2 ☽	30	31.5	6.75
7	36.3	6.1 ☽	Apr. 6	29.0	†6.9 ☽
14	38.0	5.8 ☽	9	29.9	†6.9 ☽
16	35.3	6.2	13	24.0	7.6

* Field glass † Bright sky

Observations were given up, on account of the star's nearness to the sun, after April 13.

These observations indicate that a maximum of about 5M.8 occurred 1892 March 14; the faintest observed light is 9M.9, which seems to be nearly the star's minimum light, the curve at this magnitude being apparently pretty flat.

The scale of magnitude used is the ordinary historical scale, the estimates given for the comparison-stars being made from the light-scale by a graphic process, and being, from the limited number of observations available, necessarily of a strictly provisional character. The comparison-stars, with their estimated magnitudes are as follows:

	1855.0					
		α	δ	DM.	Y.	Light
		h m s	° ′	M	M	
c =	DM. 34° 469	2 27 0.2	34 3.0	5.6	5.6	39.5
g =	33° 454	24 8.5	33 54.2	6.4	6.4	33.0
h =	32° 478	30 20.0	32 17.2	6.9	6.9	29.0
k =	33° 461	25 31.4	33 8.1	6.6	7.2	27.0
e =	DM. 33° 482	2 31 6.2	33 26.2	8.0	7.3	26.0

---

* Mr. Yendell's confirmation of the variability now permits the definitive notation to be assigned by Dr. Chandler, viz., 906 *R Trianguli*. — Ed.

	1855.0 α		δ	DM.	[illegible]	Light
	h m s		° ′	M	M	
f = DM. 33° 465	2 26 18.1		33 32.2	8.4	8.1	20.0
a = 33° 471	28 12.0		33 31.8	9.5	9.5	9.0
b = DM. 33° 467	2 27 48.4		33 38.1	9.5	10.2	3.5

c = F 15 *Trianguli.*

By comparisons of all the above observations among themselves, a period is indicated of about 290 days: this, in view of the probable difference of scales, is necessarily rough, but is given a certain weight by the interval of thirty-four years, = forty-three periods, between the date of the Bonn estimate and the time at which, as indicated by my observations, the star in its increase reached 9ᴹ.2: the period indicated by this interval is 289 days.

I would therefore suggest, as provisional elements for the star:

Maximum, 1892 March 11. + 288 days E

The star's color is a full yellow.

Dorchester, Mass., 1892 *May* 14.

FROM A LETTER OF DR. HIND TO THE EDITOR.

I have calculated elements of SWIFT's comet from Mr. BARNARD's observation on March 8, one at Toulouse, March 21, and the Paris observation of April 4, with the following result:

$$
\begin{aligned}
T &= 1892 \text{ April } 6.65862 \text{ Greenw. M.T.}\\
\pi &= 265^\circ\ 26'\ 23''.0 \\
\Omega &= 210\ 54\ 29.6 \quad \text{M. Eq. } 1892.0\\
i &= 38\ 41\ 58.9 \\
\log q &= 0.0115209
\end{aligned}
$$

For the middle place, the errors are

$$\Delta\lambda \cos\beta = -4''.7, \quad \Delta\beta = -6''.2$$

For an observation at Lyons, April 15, I find

$$\Delta\lambda \cos\beta = -13''.6, \quad \Delta\beta = -2''.9$$

Sometime since, I noticed the following near approximation of the orbits of comets of BARNARD 1884, and FINLAY 1886 (short-period comets), and WATSON's *Andromache* (no. 175), which has not been observed since 1877. I used Dr. BERBERICH's definitive orbit for BARNARD's, and Prof. KRUEGER's last orbit for FINLAY's, with the elements of *Andromache* by Dr. BIDSCHOF given in the *Berliner Jahrbuch*. In heliocentric longitude 153° 25′ (1886.0), I find

	v	$\log r$	λ	Time from Perihelion
	° ′		° ′	Y
BARNARD	−152 54.3	0.62579	+2 52.8	−1.558
FINLAY,	+145 50.2	0.62579	+2 58.1	+1.221
No. 175,	−140 0.6	0.62112	+2 54.2	−1.966

Perturbations neglected, BARNARD's and FINLAY's would be brought together at 1861.47.

In the above longitude DEVICO's comet of 1844, has

$$\log r = 0.69040, \quad \lambda = +2^\circ\ 51'.8$$

J. R. HIND.

3 *Cambridge Park, Twickenham*, 1892 *May* 2.

NOTE ON THE DOUBLE STAR FOUND UPON THE RUTHERFURD β *CYGNI* PLATES.

BY HAROLD JACOBY.

Professor LEAVENWORTH, of Haverford College, has called my attention to several measures of the double star numbered 27 and 28 in the list of stars surrounding β *Cygni*, which I have given in No. 265 of this Journal. These are:

2539 Σ.	1830.69	5.2	5.36	
Dembowski.	1867.03	2.4	5.38	
Rutherfurd Photo.	1875.7	2.1	5.32	(*A.J.* 265)
β	1878.73	3.8	5.60	

From these measures it would seem that the components have not changed their distance, and that the appearance of change upon the Columbia College negatives of 1892 April 19 is deceptive. It will be noticed that the photographic measure by Mr. RUTHERFURD agrees well with the others.

Mr. BURNHAM has found another companion of the 13th magnitude, the position of which is:

β 652 1878.93 328°.6 4″.33

Columbia College Observatory, New York, 1892 *May* 16.

NOTATION FOR THE ASTEROIDS.

Since the series of photographic discoveries of asteroids by Dr. MAX WOLF began, 1891 Nov. 28, the notation of these bodies has fallen into painful confusion. Not only has the chronological order been entirely disregarded, but no two astronomical publications have been in accord regarding the numeration.

The rapidity with which recent discoveries of the small planets have followed each other renders the proper assignment of their distinguishing numbers very difficult, and questions as to possible identity with those previously known demand not only laborious, but immediate, computation. Inasmuch as a temporary omission of the number [illegible]

with less inconvenience than is caused by the employment of an erroneous one, the numbers for the asteroids since no. 322 have been omitted in this Journal, in the hope and expectation that some mutual understanding among astronomers might be established. Since November last, ten have been found which appear not to have been previously observed. Few of these have been designated by different astronomers with accordant numbers, and it is much to be desired that the difficult task of fixing a definitive numeration should be delegated by common consent to some one authority, to which all can defer, as is now the case for the nomenclature of variable stars. Several of the recent discoveries have not been telegraphed to this country, nor have the numbers employed, in any of the cases referred to, followed the historical order. Some revision is urgently needed, for, although it is a matter of secondary importance that the order of discovery should be followed with absolute correctness, it is yet of the first importance that this order should be approximately correct, and that none should be omitted in the numeration.

The facts requisite for a definitive arrangement are not all of them accessible here. The discoveries of small planets have during recent years been made in Europe only; and the resources of the Berlin *Rechen-Institut* are now especially needful, for solving the questions of identity which are continually arising, and threaten to become still more perplexing in the near future.

The appended table of the new asteroids found since no. 321 (PALISA, 1891 Oct. 15), is the most trustworthy which we are able to compile at present. The numbers prefixed, to designate the historical order, are by no means advocated as necessarily the most desirable for definitive adoption. For a decision regarding this, some common agreement must be awaited.

Order	Discovery		Other Observations	*Astr. Nachr.*	*Astr. Journ.*
322	BORRELLY,	Nov. 27	Nov. 29, Dec. 1, 3, 4, 5, etc.	128, p. 391; 129, 23	p. 80
323	WOLF,	Nov. 28	Dec. 1, 18 (phot.)	129, pp. 47, 79	112
324	WOLF,	Dec. 22	Dec. 23 (phot.), 31, Jan. 1	pp. 15, 31	96
325	PALISA,	Feb. 25	Mar. 6, 11, 15, 16, etc	pp. 95, 146, 167, 275	136
326	WOLF,	Mar. 4	Mar. 5, 17, (phot.), 18, 19, 20, etc.	pp. 146, 167, 275	160
327	WOLF,	Mar. 18	Mar. 22, 24, 27	pp. 147, 183	
328	WOLF,	Mar. 19(*a*)	Mar. 20, 22, 25 (phot.), 28	p. 183	168
329	WOLF,	Mar. 19(*b*)	Mar. 20, 25, 30 (phot.)	p. 246	
336	PALISA,	Mar. 19	Mar. 20, Apr. 4, 25	pp. 146, 243, 275	160
331	WOLF,	Mar. 21	Mar. 24 (phot.), 26, 29, 30, etc.	pp. 183, 262, 275	168
332	CHARLOIS,	Mar. 22		p. 150	160
333	CHARLOIS,	Apr. 1		p. 183	

Nos. 308 and 322, discovered by BORRELLY, 1891 March 31 and Nov. 27, have received the names *Polyxo* and *Phaeo*, respectively.

Mr. CHARLOIS writes that he has assigned to the first asteroid discovered by him (March 22), in this quadricentennial year, the name *Columbia*.

CORRIGENDA.

Mr. BARNARD writes that he had made a clerical error in transferring the declination of the new nebula from his note-book, and asks for the following corrections upon p, 168 of no. 261.

$\Delta\delta$ *for* $+2' \, 3''.4$ *put* $+2' \, 43''.4$ | δ 1892.0 *for* $+59 \; 39' \, 2''.4$ *put* $+59 \; 39' \, 42''.4$

No. 265, p. 7, Star 2, Prec. in α, *for* 36″.2116 *put* 36″.2216

CONTENTS.

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ON THE VARIATION OF LATITUDE.

BY S. C. CHANDLER.

V.

In the preceding articles of this series, near the end of last year, it was shown: first, by comparison of simultaneous series of observations in opposite longitudes and latitudes, that the observed phenomenon of variation of latitudes is not local or regional, but terrestrial: secondly, that during the interval between 1863 and 1885 the pole of the earth's figure revolved around that of rotation, from west to east, in a period of 427 days: thirdly, that about 1730 this period was but slightly longer than a year: fourthly, that other series of observations, whose results were not then presented, made it manifest that the velocity of rotation has been slowly diminishing during the present century.

It is now proposed to present the evidence which seems to establish the following additional propositions.

1. The rate of angular motion of the pole was a maximum about 1774, when its daily change was about 1°.031, and since that epoch has been decreasing at an accelerating rate; so that, for instance, in 1850 the instantaneous velocity was diminishing continually by the one hundred and ten-thousandth part of itself, while at the present time it is diminishing by the seventy-five-thousandth part.

2. The law of the angular velocity of the polar motion may be expressed numerically as follows: let θ be the daily angular motion, and τ the interval in days from 1875 Sept. 18; then

$$(1)\qquad \theta = 0^\circ.852 - 0^\circ.000\,009\,8\,\tau - 0^\circ.000\,000\,000\,132\,\tau^2$$

3. The law of the periodic variation of latitude may be expressed as follows: let T be the time when the north pole of the earth's figure passes the Greenwich meridian; E, the number of completed revolutions between a given date t and the adopted principal epoch, and θ the daily angular motion. Then the instantaneous value of the latitude φ of a place whose mean latitude is φ_0, and whose longitude is λ, will be,

$$(2)\qquad \varphi = \varphi_0 - 0''.22\cos[\lambda + (t - T)\theta]$$

where

$$(3)\qquad T = 1875\text{ Sept. }18.5 + 422^d.56\,E + 1^d.031\,E^2 + 0^d.009\,E^3 + 0^d.000\,067\,E^4$$

$$\theta = \frac{360^\circ}{P},\ \text{in which}\ P = 423^d.62 + 2^d.0953\,E + 0^d.0271\,E^2 + 0^d.000\,268\,E^3 \qquad (4)$$

From the above law it will be seen that the period was lengthening about a day in 1840, and about two days in 1875, at each revolution.

4. During the last half-century, at least, the radius of revolution, or angular separation of the poles of figure and rotation, has remained sensibly constant.

5. The comparison of the absolute and differential determinations shows that the phenomenon pertains entirely to a variation of the zenith, and in no part to a simultaneous variation of the zenith and the astronomical pole.

These conclusions have been drawn from the discussion of a very considerable number of series of observations. The scope which the investigation has taken may be judged by the first five columns of Table I, which embraces, with tolerable completeness, all the data readily available for the purpose, in the published results of the last half century. I have in hand other similar series, but the computations are yet unfinished. I do not think they will change the character, or essentially add to the certainty, of the laws here deduced, although their inclusion may materially improve the numerical constants.

The forty-five series contained in the table have, with two exceptions, been treated in an entirely homogeneous manner, the general features of which I will now proceed to describe. The presentation of the details of results for the several series is reserved for a subsequent article. For the present it will suffice to say that for each group the data were assembled as exemplified (Vol. XI, pp. 65-70), into the limits of a single period, using a provisional approximate value of the period for that epoch. It is scarcely necessary to enlarge on the fact that the values of the semi-amplitude of the latitude-variation, r, and the observed time of minimum latitude, T, deduced from each series, will be affected only by very subordinate errors on account of error in the period thus assumed, as a first approximation.

TABLE I. PERIODICAL VARIATION OF LATITUDE: OBSERVED SEMI-AMPLITUDE AND TIME OF MINIMUM.

Series	Observatory	Date	Instrument	Stars	r	T	$\frac{\lambda}{\theta}$	p	E
					″		d		
I	Greenwich	1837. –48.	Reflex Zenith-Tube	*γ Draconis*	0.568	1842 Feb. 12	0	1	—31
II	Pulkowa	40.6–41.7	Prime-Vert. Transit	7 stars	.080	" Mar. 5	— 31	2	31
III	Radcliffe	40.0–45.0	Transit-Circle	*Polaris*	.211	" Oct. 19	+ 1	1	30
IV	Pulkowa	42.2–43.5	Vertical Circle	7 stars	.088	1843 Jan. 13	— 31	2	30
V	Pulkowa	42.1–44.8	" "	*Polaris*	.051	" Apr. 3	— 31	2	30
VI	Cape of Good Hope	42.6–44.8	Mural Circle	*α Centauri*	.311	" Apr. 26	— 19	2	30
VII	Berlin	45.1–46.9	Prime-Vert. Transit	*β Draconis*	.278	1846 Jan. 25	— 11	2	27
VIII	Radcliffe	45.0–49.9	Meridian-Circle	*Polaris*	.113	1847 Feb. 12	+ 1	1	26
IX	Washington	45.5–50.9	Prime-Vert. Transit	*α Lyrae*	.221	1848 Mar. 30	+ 81	1	25
X	Greenwich	52. –59.	Reflex Zenith-Tube	*γ Draconis*	.220	1855 Oct. 28	0	1	18
XI	Paris	56.0–62.0	Mural Circle	Nadirs	.281	1859 Jan. 31	— 3	2	15
XII	Greenwich	57. –64.	Reflex Zenith-Tube	*γ Draconis*	.193	1860 Mar. 25	0	2	14
XIII	Santiago	60.8–64.4	Meridian-Circle	*β Centauri*	.171	1862 Feb. 3	+ 79	1	12
XIV	Washington	62.3–67.2	Prime-Vert. Transit	*α Lyrae*	.164	1864 Dec. 11	+ 87	3	9
XV	Pulkowa	63.9–67.8	Vertical Circle	15 southern stars	.223	1865 Apr. 13	— 34	2	9
XVI	Leyden	64.3–68.5	Meridian-Circle	*Polaris*	.107	" May 7	— 5	2	9
XVII	Pulkowa	63.9–70.2	Vertical Circle	*Polaris*	.216	" June 17	— 34	3	9
XVIII	Greenwich	64. –69.	Reflex Zenith-Tube	*γ Draconis*	.295	1866 Aug. 6	0	2	8
XIX	Melbourne	63.5–67.5	Transit-Circle	36 polars	.141	1867 Jan. 3	—166	1	8
XX	Washington	66.0–70.6	" "	*Polaris*	.382	1868 June 16	+ 89	1	6
XXI	Melbourne	67.5–71.5	" "	36 polars	[.087]	[1869 Oct. 8]	—168	0	–
XXII	Washington	67.0–73.0	" "	δ & λ *Urs.*, 51 *Ceph.*	.340	" Oct. 1	+ 89	1	5
XXIII	Pulkowa	71.5–75.5	Vertical Circle	*Polaris*	.146	1872 June 21	— 35	3	3
XXIV	Melbourne	71.5–75.5	Transit-Circle	36 polars	.205	" Nov. 8	—170	1	3
XXV	Greenwich	70. –75.	Reflex Zenith-Tube	*γ Draconis*	[.096]	[" Sept. 5]	0	0	–
XXVI	Washington	71.6–75.7	Transit-Circle	*Polaris*	.143	1873 Jan. 21	+ 90	1	— 2
XXVII	Washington	73.0–80.0	" "	δ & λ *Urs.*, 51 *Ceph.*	.127	1876 Aug. 21	+ 91	1	+ 1
XXVIII	Melbourne	75.5–80.0	" "	36 polars	.121	1877 May 7	—173	1	1
XXIX	Cordoba	72.5–81.0	Meridian-Circle	51 polars	.128	1876 Sept. 25	+ 76	2	1
XXX	Washington	75.8–79.0	Transit-Circle	*Polaris*	.387	1877 Nov. 24	+ 92	1	2
XXXI	Pulkowa	79.9–82.1	Prime-Vert. Transit	24 zenith-stars	.067	1880 Sept. 5	— 37	2	4
XXXII	Washington	79.1–83.0	Transit-Circle	*Polaris*	.165	1881 May 6	+ 93	1	5
XXXIII	Willet's Point	80.8–85.6	Zenith-Telescope	. . . .	.273	1882 June 26	+ 90	1	6
XXXIV	Washington	82.9–84.6	Prime-Vert. Transit	*α Lyrae*	.165	1883 Dec. 2	+ 94	2	7
XXXV	Washington	80.0–87.0	Transit-Circle	δ & λ *Urs.*, 51 *Ceph.*	[.102]	['84 Feb. 29]	+ 94	0	–
XXXVI	Cambridge	81. –85.5	Almucantar	B.J. stars	.221	" Oct. 19	+ 87	2	8
XXXVII	Berlin	81. –85.	Universal Transit	7 pairs	.240	1885 Mar. 22	— 17	2	8
XXXVIII	Madison	83.5–85.9	Meridian-Circle	*Polaris*, etc.	.309	1884 Oct. 14	+110	1	8
XXXIX	Washington	83.1–87.0	Transit-Circle	*Polaris*	.406	1885 Jan. 21	+ 95	1	8
XL	Bethlehem	88.7	Zenith-Telescope	. . . .	. . .	1888 Sept. 12	+ 94	1	11
XLI	Bethlehem	89.9–90.9	" "	. . . .	.249	1889 Nov. 11	+ 94	2	12
XLII	Prague	89.2–91.4	" "	. . . .	.235	1890 Feb. 8	— 18	3	12
XLIII	Potsdam	88.9–90.3	" "	. . . .	.242	" Feb. 11	— 17	3	12
XLIV	Berlin	89.0–91.4	" "	. . . .	.210	" Feb. 12	— 17	3	12
XLV	Pulkowa	90.3–91.0	Prime-Vert. Transit	13 zenith-stars	0.256	" Feb. 11	— 38	2	+12

Each series thus gives a number of dates and corresponding observed values of $\Delta\varphi$ (O—C), in which C is an arbitrary assumed value, φ'_0, of the true mean latitude, φ_0. In the equation on p. 70,

$$\varphi = \varphi_0 - r\cos[\lambda + (t - T)\theta] \tag{5}$$

T is the time when the north pole of figure passes the Greenwich meridian. Call T' the corresponding time when it passes the local meridian. Then, since

$$T = T' + \frac{\lambda}{\theta} \tag{6}$$

$$\varphi - \varphi_0 = -r\cos(t - T')\theta$$

Further put $$T' = T'_0 + \Delta T \tag{7}$$

$$\left.\begin{array}{ll} n = \varphi - \varphi'_0 & x = \varphi_0 - \varphi'_0 \\ y = -r\sin\theta\,\Delta T & z = -r\cos\theta\,\Delta T \\ b = \sin(t - T'_0)\theta & c = \cos(t - T'_0)\theta \end{array}\right\} \tag{8}$$

and (5) becomes $$x + by + cz = n \tag{9}$$

Each observed mean value of $\Delta\varphi$(O—C) gives an equation of condition of this form. The values of the unknowns being found by least-squares, we have

$$r = \sqrt{y^2 + z^2} \quad , \quad \tan\theta\,\Delta T = \frac{y}{z} \tag{10}$$

and thence T' by eq. (7).

In this way were found the values of the observed semi-amplitude and time of minimum in columns 6 and 7 of Table I. Column 8 gives the correction to be added to T', by eq. (6), to get the corresponding time T for the Greenwich meridian, which will be found in column 3 of Table II, expressed in Julian dates. In the solution of the conditional equations (9) the probable errors were also computed, but these of course constitute but one element to be considered in estimating the proper weights for the various determinations. The adopted weights are given in column 9. Finally, in column 10, is placed the number of the epoch, E, or the number of revolutions of the pole reckoned from an arbitrary zero, corresponding to the meridian passage occurring in 1875.

In the previous articles I have more than once adverted to the fact that the period of polar revolution is gradually lengthening. This became evident so [illegible] in the investigation, indeed, that I abandoned the [illegible] method of discussing the data forward, chronologically, and decided to work backward from the present time. When, therefore, the larger portion of the material in Table I between 1860 and 1890 had been treated in the manner described, with the results there given, I made a first approximation to the law of variation within this interval, in order thus, [illegible] certainly and conveniently, to carry back the inquiry to earlier dates. It was primarily intended to limit the scope of the present paper to the determination of the law prevailing during the last half-century merely, pending the completion of the computations relating to observations anterior to 1840, which are still unfinished. I shall employ here, however, the partial and provisional results contained in the appendix to Table I.

TABLE I. APPENDIX: PROVISIONAL DATA OF EARLIER OBSERVATIONS.

Authority	Observatory	Date	Instrument	Stars	r	T	λ θ	p	E
BRADLEY,	Kew	1726.0–27.8	Zenith Sector (1)	*γ Draconis*	0.30:	1726 April 18	0	1	−151?
"	Wanstead	1727.8–31.2	" " (2)	10 zenith-stars	.50:	1729 April 27	0	1	−118?
"	Greenwich	1750.6–53.5	Mural Quadrant	*Polaris*	.35:	1751 Aug. 30	0	1	−125?
BRINKLEY,	Dublin	1808.5–11.0	Vertical Circle	*α Lyrae*	.75:	1811 June 26	+ 6	1	− 62?
"	"	1818. –22.	" "	*γ Drac.*, &c.	.50:	1819 June 11	+ 6	1	− 51?
STRUVE,	Dorpat	1822.9–27.5	Meridian-Circle	Nadir-points	0.20:	1825 May 28	−27	1	− 18?

Table II gives the values of T found from eq. (6) from the data of Table I, and their comparison with various elements hereafter derived, as will be duly explained.

TABLE II. COMPARISON OF FORMULAS WITH OBSERVED TIMES OF MINIMUM LATITUDE.

Series	E	Observed T	O − C I	O − C II	O − C III	p
			d	d	d	
I	−31	2393879	+ 18	+ 9	+ 10	1
II	31	3869	+ 8	− 1	+ 30	2
III	30	4129	− 98	−109	− 87	1
IV	30	4183	− 11	− 55	− 33	2
V	30	4263	+ 36	+ 25	+ 17	2
VI	30	4298	+ 71	+ 60	+ 82	2
VII	27	5308	− 29	− 16	− 46	2
VIII	26	5706	− 5	− 24	− 29	1
IX	25	6198	+111	+ 91	+ 80	1
X	18	2398885	+110	+ 82	+ 51	1
XI	15	2400073	+116	+ 87	+ 55	2
XII	11	0495	+140	+111	+ 80	2
XIII	12	1251	+ 97	+ 68	+ 39	1
XIV	9	2307	− 68	− 96	−118	3
XV	9	2306	− 69	− 97	−119	2
XVI	9	2359	− 16	− 44	− 66	2
XVII	9	2371	− 4	− 32	54	3
XVIII	8	2820	+ 35	+ 8	− 12	2
XIX	8	2804	+ 19	− 8	− 28	1
XX	6	3589	− 22	− 48	− 61	1
XXI	–	[3844]	–	–	–	0
XXII	5	4061	+ 34	+ 10	− 1	1
XXIII	− 3	2401931	+ 66	+ 41	+ 39	3
XXIV	− 3	2401936	+ 71	+ 19	+ 11	1
XXV	–	[5012]	–	–	–	0
XXVI	− 2	5270	− 17	− 38	− 29	1
XXVII	+ 1	6582	+ 17	+ 1	+ 8	1
XXVIII	1	6574	+ 9	− 7	0	1
XXIX	1	6599	+ 34	+ 18	+ 25	2
XXX	2	7040	+ 45	+ 31	+ 4	1
XXXI	4	7927	+ 66	+ 57	+ 64	2
XXXII	5	8300	+ 3	− 4	− [illegible]	1
XXXIII	6	8713	22	26	12	[illegible]
XXXIV	7	9244	+ 66	+ 61	+ 7[illegible]	2
XXXV	–	[illegible]	–	–	–	[illegible]
XXXVI	8	[illegible]	61	− 60	[illegible]	2
XXXVII	8	[illegible]	11	[illegible]	[illegible]	2
XXXVIII	8	[illegible]	− 45	[illegible]	[illegible]	[illegible]
XXXIX	8	2409658	+ 4[illegible]	[illegible]	[illegible]	[illegible]
XL	11	2410087	+ 32	42	[illegible]	[illegible]
XLI	12	1112	+ 7	20	[illegible]	[illegible]
XLII	12	1589	− 16	[illegible]	[illegible]	[illegible]
XLIII	12	[illegible]	− 12	+ 1	[illegible]	[illegible]
XLIV	12	1594	11	2	[illegible]	[illegible]
XLV	+12	2411575	[illegible]	− 17	12	[illegible]

Uniting the several determinations of the same epochs according to weights, we have the normal values of T in Table III.

TABLE III. NORMAL EPOCHS.

E	T	p	E	T	p
−151?	2351575	1	− 9	2402336	10
148?	2352680	1	8	2815	3
125?	2360810	1	6	3589	1
62?	2382702	1	5	4061	1
54?	2385606	1	3	4932	4
48?	2387718	1	− 2	5270	1
31	2393872	3	+ 1	6588	4
30	1231	7	2	7040	1
27	5308	2	4	7927	2
26	5706	1	5	8300	1
25	6198	1	6	8713	4
18	2398885	1	7	9241	2
15	2400073	2	8	2409593	6
14	0495	2	11	2410987	1
− 12	2401254	1	+ 12	2411392	13

Let us first confine our attention to the observations since 1840, namely to the interval between E −31 and E +12, during which there is no doubt about the number of completed revolutions between the consecutive data of Table III. Taking differences as indicated in the first column of Table IV, we arrive directly at the observed values of P in column 3, below the horizontal black line, with the corresponding mean values of E and T immediately following. From these observed values of P we get the observed values of θ in column 7. It is seen at once that these vary quite uniformly with the time, and this is confirmed by calculation. For, if we assume the form of expression, $\theta = \theta_0 - k\tau$, where $\tau = T - T_0$, in which T_0 is the time of principal epoch of minimum (1875 Sept. 18), we find by least squares, using the weights in column 6,

$$\theta = 0°.848 - 0°.00000843\,\tau \qquad (11)$$

the values of which are given in column 8, "Computed θ(I)." The agreement with the observed values is extremely satisfactory, so far as the column below the black line is concerned.

TABLE IV. DETERMINATION OF DAILY ANGULAR VELOCITY (θ) OF POLAR REVOLUTION.

Compared Epochs		Interval	Observed P	Mean		p	Observ'd	Computed θ		Comp.	ΔP
				E	T		θ	I	II	P	O − C
−151 &	−148	1105$^{\rm d}$	3 × 368.3$^{\rm d}$	−149.5	2352127	1.5	0.978	1.303	0.996	361.5$^{\rm d}$	+ 6.8$^{\rm d}$
148 "	125	8160	23 × 354.8?	136.5	2356760	11.5	1.015?	1.264	1.014	355.0	− 0.2
125 "	62	21862	63 × 347.0?	93.5	2371771	31.0	1.038?	1.139	1.033	348.5	− 1.5
62 "	54	2904	8 × 363.0	58	2384154	4.0	0.992	1.033	1.004	358.6	+ 4.4
54 "	48	2142	6 × 357.0	51	2386677	3.0	1.009	1.012	0.993	362.5	− 5.5
48 "	31	6121	17 × 360.2?	39.5	2390810	12.8	1.000?	0.977	0.971	370.8	−10.6
31 "	25	2326	6 × 387.7	28	2395035	4.5	0.929	0.941	0.945	381.0	+ 6.7
30 "	18	4654	12 × 387.8	24	6558	10.5	.928	.928	.935	385.0	+ 2.8
27 "	15	4765	12 × 397.1	21	7690	12.0	.907	.919	.925	389.2	+ 7.9
26 "	14	4789	12 × 399.1	20	8100	8.0	.902	.916	.922	390.5	+ 8.6
25 "	12	5056	13 × 388.9	18.5	2398726	6.5	.926	.910	.917	392.6	− 3.7
18 "	9	3451	9 × 383.4	13.5	2400610	8.2	.939	.894	.902	399.1	−15.7
15 "	8	2742	7 × 391.7	11.5	1444	8.4	.919	.887	.895	402.2	−10.5
14 "	6	3094	8 × 386.8	10	2042	5.3	.931	.882	.890	404.5	−17.7
12 "	5	2807	7 × 401.0	8.5	2657	3.5	.898	.877	.885	406.8	− 5.8
9 "	3	2596	6 × 432.7	6	3634	17.1	.832	.869	.876	411.0	+21.7
8 "	−2	2455	6 × 409.2	5	4042	4.5	.880	.866	.872	412.8	− 3.6
6 "	+1	2999	7 × 428.4	2.5	5088	5.6	.840	.857	.862	417.6	+10.8
5 "	2	2979	7 × 425.6	− 1.5	5550	3.5	.846	.853	.858	419.6	+ 6.0
3 "	4	2995	7 × 427.9	+ 0.5	6430	9.3	.842	.846	.849	424.0	+ 3.9
− 2 "	5	3030	7 × 432.9	1.5	6785	3.5	.832	.843	.846	425.5	+ 7.4
+ 1 "	6	2125	5 × 425.0	3.5	7650	5.0	.847	.835	.837	430.1	− 5.1
2 "	7	2201	5 × 440.2	4.5	8140	3.3	.818	.831	.832	432.7	+ 7.5
4 "	8	1666	4 × 416.5	6	8760	6.0	.864	.826	.826	435.8	−19.3
5 "	11	2687	6 × 447.8	8	2409644	3.0	.804	.819	.816	441.2	+ 6.4
+ 6 "	+12	2679	6 × 446.5	+ 9	2410052	5.6	0.806	0.815	0.812	443.3	+ 3.2

It thus appears to be demonstrated, as a preliminary result, that *the instantaneous rate of angular motion of the pole has been diminishing during the last half century, at a sensibly uniform rate, by its one hundred thousandth part.*

Let us now go further back. Compare the column "Observed θ." above the black line, with the corresponding values computed from eq. (11) in the succeeding column. The numeration of the epochs between BRADLEY'S Kew and his Wanstead observations, between BRINKLEY'S two epochs, and between these and STRUVE'S, is open to no doubt. These

correspond to the 1st, 4th and 5th values of θ. We are thus able to fix approximately the numeration of the epochs which furnish the 2d, 3d and 6th values, subject only to the error arising from a possible error of unity in the differences of E in the first part of the third column.

It is manifest that, for these earlier observations, the rate of the variation in θ is not the same as we have just found to prevail subsequent to 1840; and that, if we are to satisfy the observations, we must assume a law of the form,

$$(12) \qquad \theta = \theta_0 - k\tau - k'\tau^2$$

Determining the values of k and k' on this hypothesis we find,

$$\theta = 0°.848 - 0°.0000098\,\tau - 0°.000000000132\,\tau^2$$

This is the same as eq.(4), p. 17, except the constant term, which was subsequently slightly modified to conform to the solutions, to be presently given, which determine the period directly. The values of eq.(4) are placed in column 9 of Table IV; and the corresponding values of P and their differences from the observed quantities, are in the last two columns.

The doubt about the periods elapsed between some of the earlier series, above spoken of, affects slightly the numerical value of the coefficients, but not the character of the general law incorporated in eq.(12), whose existence I therefore regard as established, from the observations of the past one hundred and sixty years. I am well aware of the grave importance of this conclusion on account of its incompatibility with the theory of the earth's rotation heretofore universally accepted, even as modified by Prof. Newcomb's considerations as to the earth's elasticity and the mobility of the ocean; for even the latter requires a constancy in the angular velocity of the motion of the principal axis of inertia relatively to the instantaneous axis. Nevertheless, I do not see how we can interpret the results of observation in any other reasonable way; and unless the above interpretation can be successfully disproved, the theory cannot be considered complete until the result here reached is accounted for.

Integrating eq.(12), we have the total angle described in E revolutions,

$$360° E = \theta_0\tau - \tfrac{1}{2}k\tau^2 - \tfrac{1}{3}k'\tau^3$$

whence, putting $P_0 = \dfrac{360°}{\theta_0}$ and T_0 for the time of passing the Greenwich meridian at the principal epoch,

$$T = T_0 + P_0 E + \tfrac{1}{2}\frac{k}{\theta_0}\tau^2 + \tfrac{1}{3}\frac{k'}{\theta}\tau^3$$

Developing in powers of E, neglecting those higher than the 5th, and introducing the numerical values of k and k' already found, we find,

$$\begin{aligned} T = T_0 + P_0 E &+ 1^d.034\ E^2 + 0^d.009\ E^3 \\ (13) \qquad &+ 0^d.000067\ E^4 + 0^d.0000018\ E^5 \end{aligned}$$

It remains to determine T_0 and P_0 from the data of Table II. First, comparing column 3 with the assumed approximate elements

$$T = 2406137^d + 127^d E + 1^d.0\,E^2 \qquad \text{(I)}$$

we have column I of O — C. To ascertain how closely the observations may be represented by a period varying uniformly with the time, a solution by least squares, with the weights given in the last column, gave

$$\begin{aligned} T = 2406151^d.4 &+ 125^d.25\,E + 0^d.955\,E^2 \qquad \text{(II)} \\ \pm 5.5 \qquad &\pm 0.19 \qquad \pm 0.023 \end{aligned}$$

Adopting the numerical values of the cofficients of E^3, E^4, E^5, as found by eq.(13), introducing the corresponding rigorous equation of condition into the conditional equations, and solving for T_0 and P_0, we have

$$\begin{aligned} T = 2406150^d.5 + 122^d.56\ E &+ 1^d.031\ E^2 \qquad \text{(III)} \\ &+ 0^d.009\ E^3 + 0^d.000067\ E^4 \end{aligned}$$

which are adopted as final. The finite difference gives P, as in eq (4). The comparison of elements II and III is given under O — C in Table II. A study of the residuals presents some instructive points, and will be taken up later.

An examination of the column r in Table I yields two interesting inferences with regard to the amount of the angular separation of the axes of figure and rotation. Table V gives the means, by weights, of this quantity, in three chronological groups, and separately for the absolute and differential determinations. From this we are able to infer that it has remained sensibly constant during the last half century. Whether this inference can be extended to earlier epochs must remain an open question, until we obtain more precise figures than the rude estimates given in the appendix to Table I.

Table V. Angular Separation of Poles.

Interval	Absolute		Differential		All	
	p	r	p	r	p	r
1840–60	4	0″.182	11	0″.230	15	0″.217
1860–80	20	.198	10	.209	30	.202
1880–91	3	.293	22	.215	25	.224
Means	27	0″.206	43	0″.218	70	0″.213

It does not seem superfluous to adduce another significant fact, the substantial equality of this element as obtained by the absolute and differential methods. This could not subsist if the phenomenon were of the nature of a revolution of both axes about a common point in the celestial sphere. We may conclude that it is *entirely* due to a rotation of the instantaneous axis relative to a fixed point in the earth's crust. In this there is an entire accord with theory, according to which only one three-hundredth part of the observed radius of 0″.22, or 0″.0007, is due to an actual nutation of the rotation-axis.

I desire to make grateful acknowledgement of an appropriation by the Trustees of the WATSON fund of the National Academy, by means of which I have been enabled to make the preceding investigations, and expect to continue them in the future; and also to recognize publicly the skilful and most efficient service of my assistant, Miss F. GERTRUDE WENTWORTH, who has taken an equal share with me in these computations.

ORBIT OF *NEPTUNE'S* SATELLITE.

By ASSISTANT ASTRONOMER A. HALL, JR.

[Communicated by permission of Captain F. V. McNAIR, Superintendent Naval Observatory.]

The following observations of *Neptune's* satellite, made during the opposition of 1891, 92 with the 26-inch equatorial of the Naval Observatory, are communicated now, since they are of interest as confirming the reality of the slow motion, nearly proportional to the time, of the orbit-plane of the satellite with respect to the orbit of *Neptune*.

Mr. A. MARTH, in Vol. XLVI of the *Monthly Notices of the R. Astr. Soc.*, has called attention to these curious changes, and Mr. TISSERAND, in Tome CVII of the *Comptes Rendus*, has shown that they may result from a slight flattening of the planet.

These observations were made in the following manner: first, four settings in position-angle were made, then three double distances were observed, and then four more position-angles. As printed, the observations are completely reduced, the distances having been reduced when necessary, to the time of the position-angles. The measures of Oct. 28, and the first measures of Dec. 5, Dec. 10, and Jan. 17, were made by Prof. HALL. The value of a micrometer revolution is $R = 9''.9198$, determined by measuring the difference of declination of the stars *Electra* and *Celaeno* in the *Pleiades*. Though there is little uncertainty with regard to the places of the stars, yet the value of a revolution is quite accurate enough for these reductions. For Prof. HALL's observations $R = 9''.9370$, determined by him in the same way.

The following circular elements, referred to the equator, were used, with which to compare the observed places:

1883.0. Washington Mean Time.

Dist. from node on equator at epoch,	$u = 209^\circ.99$
Inclination	$I = 120^\circ.052 + 0^\circ.0005\,t$
Node	$N = 184^\circ.316 + 0^\circ.0095\,t$
Periodic time	5.8769 days
Mean distance	$a = 16''.300$

where t is expressed in years. Under the observations of the satellite Δp and Δs are taken in the sense C — O. The equations of condition for obtaining corrections to these elements were solved separately for the position-angles and distances. The residuals are given, found by substituting the values of the corrections thus obtained. The probable error of one equation as derived from a comparison of the observations among themselves is $\pm 0''.2631$ for the position-angles, and $\pm 0''.2643$ for the distances. In forming the equations of condition the same weight was given to each equation.

OBSERVATIONS OF NEPTUNE'S SATELLITE.

Date	Washington M.T.	Observed p	Δp	Residual	Observ'd s	Δs	Residual	Remarks
1891	h m		″					
Oct. 28	11 17.5	63.46	+1.37	+0.428	16.65	—0.01	+0.387	faint
Nov. 7	11 32.1	193.00	+0.73	—0.613	11.80	—0.25	—0.535	faint
9	11 8.1	59.20	+0.21	—0.781	16.55	+0.38	+0.607	mist, faint
11	10 29.3	276.91	+0.88	—0.271	11.95	+0.17	+0.776	moonlight, mist, faint
29	10 33.7	255.55	+1.49	+0.310	15.42	—0.47	+0.102	clock running badly
30	9 26.7	221.55	+1.55	+0.224	16.46	—0.49	—0.229	
Dec. 1	9 49.6	145.60	+1.98	+0.741	. .	. .	. .	too faint for distance
5	9 5.0	252.31	+1.68	+0.494	15.87	—0.55	+0.004	faint
5	9 31.3	254.76	+0.84	—0.348	16.26	—0.82	—0.273	faint
8	9 40.7	73.70	+0.40	—0.503	16.44	—0.64	—0.122	very faint, moonlight
9	9 43.2	35.05	+1.06	—0.033	14.73	+0.07	—0.122	faint, moonlight
10	9 21.6	310.70	+1.41	+0.142	9.81	—0.16	—0.131	faint, moonlight
10	9 49.1	309.86	+1.26	—0.004	. .		. .	faint, moonlight
17	8 26.7	246.51	+1.01	—0.181	16.82	—0.41	+0.047	faint, seeing rather poor
18	9 10.6	201.80	+1.59	+0.257	13.82	—0.22	—0.312	
28	8 1.2	284.60	+0.95	—0.237	11.59	—0.68	—0.110	mist
30	8 17.1	190.90	+1.76	+0.436	11.64	+0.21	—0.005	faint
31	8 15.3	101.10	+0.65	—0.260	11.57	—0.15	+0.191	mist, delayed by clouds

Date	Washington M.T.	Observed p	$\Delta''p$	Residual	Observ'd s	Δs	Residual	Remarks
1892	h m	°	"	"	"	"		
Jan. 7	8 45.6	51.65	+0.98	−0.032	16.96	−0.25	−0.140	moonlight
16	7 24.9	224.90	+1.62	−0.329	16.11	+0.19	+0.422	clock running [illegible]
17	6 36.3	168.05	+1.19	−0.106	9.12	+0.58	+0.223	extremely faint, misty
17	7 20.8	165.40	+1.10	−0.171	9.06	+0.49	+0.147	very faint, mist
20	8 11.6	335.25	+1.01	−0.223	9.25	−0.08	−0.014	
21	6 37.0	258.90	+1.12	−0.033	15.27	−1.13	−0.559	unsteady
27	7 3.6	253.00	+1.13	−0.037	15.92	−0.87	−0.334	faint
Feb. 5	7 11.8	65.55	+1.27	+0.365	16.54	−0.59	−0.100	moonlight, distances [illegible]
11	6 13.0	61.95	+1.30	+0.379	16.81	−0.56	−0.139	windy
12	6 56.6	21.35	+1.46	+0.358	. . .	. . .	. . .	windy, too faint for distance
13	7 21.2	285.50	+1.11	+0.261	10.82	−0.60	−0.066	
15	7 19.5	200.15	+0.70	−0.590	11.86	+0.28	+0.090	faint
17	7 8.4	58.50	+0.95	+0.003	17.44	−0.98	−0.655	somewhat faint
Mar. 3	8 1.3	226.90	+0.91	−0.347	15.30	+0.57	+0.792	very faint, unsteady

NORMALS FROM POSITION-ANGLE EQUATIONS.

$$
\begin{array}{llllll}
+1.3635\,\Delta N & +0.3931\,\Delta J & -1.1494\,\Delta u & +3.0218\,ae\cos\omega & +0.2381\,ae\sin\omega & +0.2007 = 0\\
 & +5.9596 & -5.3187 & +5.0229 & +2.5647 & +9.8494\\
 & & +17.8161 & -1.6208 & +5.2978 & -27.3945\\
 & & & +38.3378 & +8.1650 & +1.3146\\
 & & & & +32.9719 & -9.7220
\end{array}
$$

NORMALS FROM DISTANCE EQUATIONS.

$$
\begin{array}{lllllll}
+3.9807\,\Delta N & +0.8747\,\Delta J & -3.0031\,\Delta u & -2.0921\,ae\cos\omega & -0.6977\,ae\sin\omega & -3.9430\,\Delta a & +3.4364 = 0\\
 & +3.8053 & +1.0879 & -3.6116 & -2.1775 & -1.6134 & -0.0740\\
 & & +3.1192 & -0.0567 & -0.5109 & +1.1430 & -2.9747\\
 & & & +22.6210 & +11.5139 & +6.0536 & -2.3779\\
 & & & & +11.2652 & +3.6538 & -0.5375\\
 & & & & & +21.4201 & -6.6829
\end{array}
$$

Solving these normals, and combining the two sets of results according to their probable errors, we have for the final corrections to the circular elements, and also for the corrected elements, the following:

$$
\begin{aligned}
\Delta N &= +1.332 \quad \pm 0.4513\\
\Delta J &= -1.511 \quad \pm 0.4193\\
\Delta u &= +1.781 \quad \pm 0.2735\\
\Delta a &= +0''.3093 \quad \pm 0''.07199
\end{aligned}
$$

1891 Dec. 30.0 Washington Mean Time.

$$
\begin{aligned}
N &= 185.731 \quad \pm 0.4513\\
J &= 118.545 \quad \pm 0.4193\\
u &= 264.56 \quad \pm 0.274\\
e &= 0.008955 \quad \pm 0.0029139\\
\omega &= 201^\circ.20 \quad \pm 15^\circ.962
\end{aligned}
$$

$$a = 16''.6093 \ \pm 0.07199 \text{ at distance } 30.05728$$

Combining the corrected value of u, given above, with the value deduced from LASSELL's and MARTH's observations of 1863–64, by Prof. HALL, we have for the mean daily motion of *Neptune*'s satellite, $61^\circ.25717538$

and for the period, 5.876834 mean solar days.

The period employed for comparing the observations with the assumed elements was that of Prof. NEWCOMB's tables, 5.8769 days.

Prof. HALL found from his observations of 1881–84 the period 5.876839 days, agreeing almost exactly with the above.

After the satellite has been observed through several [illegible] oppositions, careful comparisons should be made with all the old observations, and new tables of u should be computed. In the mean time, for the purpose of identifying the satellite and computing equations of condition, it will be sufficient for some years to come to add 5° to the u of Prof. NEWCOMB's tables.

From the corrected value of a we find for the mass of *Neptune*, the mass of the sun being unity, $m =$ [illegible]

If we count the node and inclination of the satellite's orbit on the orbit of *Neptune*, for which $N =$ [illegible], $J = 22^\circ.339$, 1880.0, and reckon the node from the ascending node of *Neptune*'s orbit on the equator, we have node $= 182^\circ.85$, inclination $= 110^\circ.86$. Combining these values with the results pointed out by Mr. MARTH, we have for the longitude of the node on *Neptune*'s orbit, and for the inclination of the two orbits,

		Longitude of Node	Inclination of the two orbits
Malta	1852.9	172.[illegible]1	118.[illegible]
	1864.0	177.12	116.1[illegible]
Washington	1874.0	179.[illegible]	114.[illegible]4
	1883.0	181.62	112.58
	1892.0	182.85	110.86

Thus the Washington observations for 1892 strongly confirm the slow motion of the orbit-plane of the satellite with respect to the orbit of *Neptune*. [illegible]

are somewhat rough, on account of my inexperience in measuring such difficult objects as *Neptune's* satellite, and though I have not very much confidence in the value given above for the mass, still, there can be little doubt, I think, about the correction to the period, and the changes of N and J. It will be well worth while to continue the observations of the satellite in order to follow these changes, as well as to determine the period, the mass, and the eccentricity. The satellite can now be followed all the way round the planet, and the apparent orbit is opening.

THE SECULAR VARIATION OF LATITUDES,

BY GEORGE C. COMSTOCK.

The criticisms of the plan for an investigation of a possible secular variation of latitudes, which are contained in No. 262 of this Journal, rest upon a misapprehension for which I am perhaps responsible, in not having set forth in sufficient detail the method by which the difficulties apparently arising from an imperfect knowledge of stellar proper motions may be overcome. It is the peculiar excellence of the proposed method that the declinations and proper motions of the stars employed may be in error by any assignable quantity without sensibly impairing the precision of the results obtained, since the declinations are completely eliminated from these results.

To illustrate the mode of elimination, let there be two observing stations upon approximately the same parallel of latitude, but in longitudes λ' and λ'', respectively. If the latitudes of these stations φ' and φ'' be simultaneously determined by observations of the same stars, the difference $\varphi'-\varphi''$ will be entirely independent of the declinations employed. If terrestrial latitudes are constant, this difference $\varphi'-\varphi''$ will be constant, but if there is a secular change in the position of the rotation-axis, $\varphi'-\varphi''$ will in general vary with the time. Thus if λ_0 denote the longitude of the meridian along which the pole is moving, and p be the amount of its annual motion, we shall find after a lapse of t years

$$(\varphi'-\varphi'')_t = (\varphi'-\varphi'')_0 + pt \cdot 2 \sin \tfrac{1}{2}(\lambda'-\lambda'') \sin[\tfrac{1}{2}(\lambda'+\lambda'')-\lambda_0]$$

Any pair of stations which satisfy the conditions above imposed will furnish an equation of this form, independent of the star-places, even though different stars should be observed at the two epochs; and since p and λ_0 are the only unknown quantities involved, two such equations are sufficient to determine the motion of the pole, or to show that no secular motion exists. The minimum number of stations which will suffice for a complete investigation of the problem is three, and they will be most advantageously placed if 120° apart in longitude. The great width of the Pacific Ocean requires for the fulfillment of this condition that one of the stations shall be placed in eastern Asia, and obviously it will be advantageous to select a station at which observations satisfying the above requirements have already been made. Such a selection of stations I have indicated in previous papers, and have there pointed out that since the nearly simultaneous observations at Asiatic and American stations depend upon observations of different stars, it will be necessary to make a careful discussion of the star-places; but any systematic error in the adopted proper motions will be eliminated from the final result, since such an elimination is always effected by taking the difference of simultaneous latitude-determinations.

The neglect of this principle, or failure to perceive it, has produced most of the criticism which has been directed against the proposal to investigate the motion of the pole by differential methods. The superiority of these methods over those which depend upon absolute latitude-determinations arises in part from the greater freedom of the observations from possible sources of systematic error, and in part from the circumstance that the variation which is to be measured by the differential method is about twice as great as the corresponding quantity in the case of absolute determinations. Thus if three stations be placed in longitudes differing among themselves by 120°, then whatever may be the direction of motion of the pole, there will be two of these three stations which will furnish an annual variation of $\varphi'-\varphi''$ greater than $\frac{3}{2}p$, where p is the annual motion of the pole, while under the most favorable conditions possible the variation to be detected by absolute determinations of latitude at a single station cannot exceed p, and in general will be less than $\frac{2}{3}p$. If the annual motion of the pole be no more than 0″.01, a well arranged programme of zenith telescope observations will be capable of showing this motion within a period of twenty years.

In reply to the criticism of my treatment of the Washington prime-vertical observations, I wish to state that in my discussion I did employ as the seconds of assumed latitude 38″.80, not through inadvertence, but upon the authority of an official letter from Lieut. TAYLOR transmitted to me by the Superintendent of the Naval Observatory. Lieut. TAYLOR made the reduction of the observations, and in his letter states that "The φ was that adopted for the Observatory, viz: 38° 53′ 38″.80." I have endeavored to ascertain the cause of the discrepancy between this value and that given by Prof. BROWN, 38″.34, but have been unable to obtain any information in regard to it, owing to the present serious illness of Lieut. TAYLOR.

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A CATALOGUE OF STARS WITH PROPER MOTION OF HALF A SECOND AND UPWARDS.

BY J. G. PORTER.

The following list of stars with a yearly proper motion of half a second or over is taken from a still more extensive catalogue which I hope soon to publish. With the exception of the fundamental stars the motions have not been recomputed, and in many cases also new observations were secured, thus adding materially to the trustworthiness of the results.

No.	Name	Mag.	R. A. 1900.0	Decl. 1900.0	Proper motion in R. A.	Proper motion in Decl.	Proper motion in Gr. Cir.	Pos.-Angle
1	Lalande 47231	8	0 0 24	+15 15.5	+0,081	—0.13	0,90	[illegible]
2	β *Cassiopeae*	2	3 50	+58 35.9	+ ,066	—0.19	0,54	110.4
3	Groombridge 34	8	12 40	+43 27.3	+ ,260	+0.39	2.86	82.2
4	ζ *Tucanae*	4	14 52	—65 27.8	+ ,273	+1.15	2.05	55.9
5	Lalande 475	8.5	19 20	—27 35.0	+ ,053	+0.01	0,70	86.7
6	Lacaille 75	7	19 48	—51 35.5	+ ,052	—0.30	0,57	122.0
7	β *Hydri*	3	20 30	—77 49.0	+ ,712	+0.32	2.27	81.9
8	Lacaille 127	7.5	28 50	—35 32.1	,000	—0.53	0,53	180.0
9	Piazzi O. 130	5.5	32 13	—25 19.1	+ ,104	—0.03	1.41	91.2
10	Piazzi O. 137	7.5	34 0	+ 2 31.6	+ ,049	+0.29	0,79	68.5
11	54 *Piscium*	6	34 10	+20 42.7	— ,031	—0.58	0,61	231.6
12	Lalande 1015	7	35 20	+39 39.4	+ ,033	—0.72	0,81	152.1
13	Lalande 1065, 6	6	35 31	—24 20.7	+ ,055	—0.32	0,79	114.0
14	Lacaille 172	5	35 15	—60 1.0	+ ,120	+0.13	1,00	64.5
15	Lalande 1198	8.5	39 57	+ 1 15.2	— ,001	—0.63	0,63	181.4
16	η *Cassiopeae*	4	43 3	+57 17.4	+ ,135	—0.48	1.19	113.8
17	Mayer 20	6	43 8	+ 1 46.0	+ ,050	—1.15	1.37	146.9
18	Lalande 1353	7.5	0 11 27	—23 45.7	+ ,039	+0.13	0,55	76.2
19	μ *Cassiopeae*	5.5	1 1 37	+54 25.8	+ ,389	—1.57	3.75	114.8
20	Lalande 1961	8.5	2 11	+22 26.0	+ ,008	—0.51	0,52	167.7
21	Lalande 1966	8	3 17	+61 0.7	+ ,095	0,00	0,69	90.0
22	ν *Phoenicis*	5.5	10 10	—46 3.9	+ ,066	+0.17	0,71	76.2
23	Weisse-Bessel I. 161	8	13 32	— 1 23.1	+ ,030	—0.30	0,54	123.7
24	Lalande 2387	9	14 1	— 9 27.2	— ,018	—0.50	0,57	208.0
25	Lalande 2450	7	16 52	+18 9.6	+ ,040	0,00	0,57	90.0
26	Lalande 2682	8	23 35	+21 12.6	+ ,035	—0.19	0,53	111.2
27	Lalande 3022	8	33 56	+27 35.9	+ ,038	+0.13	0,53	75.7
28	Fedorenko 263	7	34 10	+66 21.6	+ ,119	—0.23	0,76	107.7
29	41 H. *Andromedae*	5	35 12	+42 6.7	+ ,073	—0.15	0,82	100.5
30	107 *Piscium*	5.5	37 1	+19 47.0	— ,021	—0.67	0,73	204.1
31	τ *Ceti*	3.5	39 25	—16 27.9	— ,122	+0.86	1.95	296.1
32	Piazzi I. 159	6	40 31	+63 21.5	+ ,085	—0.21	0,62	112.8
33	Oeltz.-Argelander 1137.8	8.5	48 2	—22 55.7	+ ,067	0,00	0,92	90.0
34	χ *Eridani*	4	1 52 4	—52 6.4	+ ,072	+0.30	0.72	65.5
35	Lalande 3922. 3	7.5	2 2 29	— 1 5.0	— ,022	—0.38	0,50	[illegible]
36	Lacaille 661	6.5	6 21	—51 18.8	+ ,230	+0.76	2.28	70.6
37	Bradley 3227	7.5	7 31	+67 12.8	+ ,080	—0.30	0.56	122.8
38	Weisse-Bessel II. 95	8.5	2 9 28	— 1 10.0	+0,065	0,00	0,97	90.0

No.	Name	Mag	R. A. 1900.0	Decl. 1900.0	Proper motion in R. A.	Proper motion in Decl.	Proper motion in Gr. Cir.	Pos.-Angle
			s	′	s		″	
39	Lalande 1141	7	2 9 41	+23 48.6	+0.012	−0.17	0.60	106.3
40	*δ Trianguli*	5.5	10 57	+33 16.0	+ .091	−0.23	1.15	101.5
41	Piazzi II, 123	6.5	30 36	+ 6 21.6	+ .123	+1.15	2.34	51.8
42	Lalande 1855	7.5	32 35	+30 23.6	− .035	−0.10	0.60	228.4
43	Oeltz.-Argel. 1739–41	8	36 17	−30 34.0	+ .051	0.00	0.66	90.0
44	Weisse-Bessel II, 927	8	55 15	+ 5 35.6	+ .044	−0.15	0.68	102.8
45	Lalande 5490–6	7	55 58	+61 19.9	+ .406	−0.67	1.01	131.4
46	*. Fornacis*	6	2 57 19	−28 28.4	+ .024	−0.44	0.50	145.7
47	*ι Persei*	4	3 1 51	+49 13.9	+ .127	−0.06	1.25	92.7
48	Lalande 5761	8	2 32	+25 58.2	− .013	−0.88	0.90	191.6
49	12 *Eridani*	3.5	7 19	−29 22.9	+ .024	+0.66	0.73	25.2
50	Weisse-Bessel III, 113	8.5	9 22	+ 8 37.2	+ .031	−0.11	0.62	131.7
51	*ζ¹ Reticuli*	5.5	15 36	−62 57.5	+ .196	+0.62	1.48	65.2
52	Lacaille 1060	4	15 56	−43 27.1	+ .271	+0.76	3.05	75.5
53	*ζ² Reticuli*	5.5	16 2	−62 53.3	+ .189	+0.64	1.41	63.6
54	Lalande 6320	8	20 1	− 5 41.7	− .018	−0.82	0.86	198.2
55	Lalande 6429	8	23 19	−20 9.7	+ .038	+0.29	0.64	61.8
56	Lacaille 1143	6.5	27 38	−63 17.4	+ .050	+0.36	0.50	43.4
57	*ε Eridani*	3	28 13	− 9 47.8	− .068	+0.01	1.01	270.6
58	10 *Tauri*	4.5	31 46	+ 0 5.1	− .016	−0.50	0.55	205.6
59	Weisse-Bessel III, 617	7.5	35 17	− 3 32.4	+ .050	−0.24	0.79	107.7
60	*δ Eridani*	3	38 27	−10 6.1	− .008	+0.74	0.75	350.8
61	Lalande 6888, 9	8	40 12	+41 9.0	+ .053	−1.24	1.38	154.2
62	*τ⁶ Eridani*	4	42 33	−23 32.7	− .013	−0.53	0.56	198.8
63	Lalande. 7036	8	46 27	+60 52.6	+ .060	−0.23	0.50	117.6
64	Groombridge 745	8.5	48 21	+75 53.1	+ .102	−0.52	0.64	114.6
65	Lalande 7443	8.5	3 56 32	+35 1.9	+ .110	−1.35	2.19	128.1
66	40 *Eridani*	5	4 10 40	− 7 48.5	− .149	−3.46	4.11	212.7
67	Groombridge 864	7.5	31 34	+41 56.1	+ .052	−0.44	0.73	127.2
68	Groombridge 881	7.5	44 22	+45 40.7	+ .037	−0.56	0.68	145.1
69	Weisse-Bessel IV, 1189	7	4 55 51	− 5 52.3	+ .040	−1.10	1.25	151.4
70	101 *m Tauri*	5.5	5 1 32	+18 30.7	+ .037	+0.03	0.53	86.8
71	*λ Aurigae*	5	12 6	+40 0.6	+ .045	−0.66	0.84	141.7
72	Lalande 9960, 1	7.5	11 8	− 3 10.9	+ .018	+0.11	0.73	81.3
73	Lalande 10299	8	23 29	− 3 33.6	− .019	−0.84	0.89	198.4
74	Weisse-Bessel V, 592	8.5	26 23	− 3 41.7	+ .047	−2.12	2.23	164.7
75	Groombridge 990	8	30 24	+51 22.8	− .059	+0.09	0.56	279.3
76	Piazzi V, 146	6.5	33 14	+53 26.4	+ .001	−0.55	0.55	179.0
77	Lalande 10797, 8	7.5	39 9	+37 15.4	+ .042	−0.52	0 72	136.1
78	*π Mensae*	6	45 8	−80 32.6	+ .087	+1.10	1.28	10.8
79	*δ Leporis*	4	47 1	−20 53.3	+ .016	−0.65	0.69	161.3
80	Lalande 11196	7	50 21	+13 55.3	+ .032	−0.50	0.69	136.8
81	Lacaille 2106	5	5 53 20	−63 7.2	+ .023	+0.48	0.50	17.4
82	2341. *Camelopardalis*	5.5	6 29 10	+79 40.3	− .025	−0.66	0.66	186.1
83	*α Canis Maj.*	1	40 45	−16 34.7	− .037	−1.20	1.31	203.8
84	Lalande 13284, 5	7	47 26	− 5 3.2	− .038	0.00	0.57	270.0
85	Lacaille 2501	6	49 35	−28 24.2	+ .025	−0.18	0.58	145.5
86	Weisse-Bessel VI, 1500	8	51 24	+ 1 18.5	+ .007	−0.56	0.57	169 9
87	Lalande 13127	8.5	54 0	+48 31.8	+ .059	−0.40	0.71	124.1
88	Piazzi VI, 305	6.5	6 57 9	+29 30.3	+ .013	−0.80	0.82	168.0
89	Lalande 13849	7	7 4 11	+21 25.2	− .011	−0.50	0.52	196.7
90	Lalande 14146	8	11 16	−12 52.7	− .036	+0.13	0.55	283.8
91	Lacaille 2740	6.5	14 37	−46 48.9	− .018	+0.57	0.60	342.5
92	*α Canis minoris*	1	34 4	+ 5 28.9	− .047	−1.03	1.25	214.2
93	*β Geminorum*	1.5	39 12	+28 16.1	− .048	−0.05	0.63	265.5
94	28 *Camelopardalis*	6.5	39 45	+80 31.0	− .200	+0.02	0.50	272.3
95	*T Puppis*	5	39 52	−44 55.2	− .003	−0.55	0.55	183.1
96	Lacaille 2957	6	41 51	−33 58.6	− .021	+1.66	1.68	351.1
97	Lalande 15290	8.5	47 10	+30 54.8	+ .057	−1.83	1.97	158.3
98	Lalande 15547	8	53 41	+21 7.8	+ .015	−0.55	0.59	159.1
99	Oeltz.-Argel. 7734–5	8	7 53 50	−25 21.0	+0.032	−0.28	0.52	122.5

No.	Name	Mag.	R.A. 1900.0	Decl. 1900.0	Proper Motion in			
					R.A.	Decl.	Gr. C.	Pos.-Angle
100	Lalande 15565	7.5	7 54 21	+29 31.1	−0.011	−1.18	1.19	186.8
101	Lacaille 3122	6	55 56	−60 2.1	+ .073	+0.12	0.56	77.7
102	Piazzi VII. 321	6.5	8 5 23	+32 46.3	− .036	−0.68	0.82	213.5
103	Weisse-Bessel VIII. 181, 2	8.5	11 59	+30 56.0	− .024	−0.84	0.90	200.3
104	Lalande 16304	6.5	13 39	−12 17.6	+ .016	−1.00	1.03	166.5
105	Lacaille 3386	6.5	28 57	−31 10.9	− .088	+0.69	1.32	301.4
106	Lalande 17046	8	34 23	+11 53.4	− .009	−0.50	0.52	194.6
107	Lalande 17161	8.5	38 35	+42 3.1	− .025	−0.63	0.69	204.0
108	Fedorenko 1384	9	45 59	+71 10.9	− .280	−0.35	1.40	255.6
109	*ρ Cancri*	6	46 39	+28 42.8	− .037	−0.24	0.55	243.9
110	*ι Ursae Majoris*	3	52 22	+48 26.1	− .044	−0.25	0.51	240.4
111	10 *Ursae Majoris*	4	8 54 9	+42 10.7	− .040	−0.26	0.52	240.0
112	Lalande 18067	7	9 3 46	−14 41.1	− .034	−0.23	0.54	244.8
113	*π Cancri*	6.5	6 49	+15 23.9	− .038	+0.25	0.60	294.5
114	Fedorenko 1457. 8	7.5	7 35	+53 7.0	− .175	−0.62	1.69	248.5
115	Lalande 18286	8	11 57	+28 59.6	+ .005	−0.52	0.52	172.4
116	Lalande 18397	7	16 8	+40 38.2	− .033	−0.40	0.55	223.5
117	*θ Ursae Majoris*	3	26 10	+52 8.0	− .104	−0.56	1.11	239.7
118	11 *Leonis minoris*	6	29 40	+36 15.7	− .059	−0.27	0.77	249.1
119	Lalande 19022	8	37 7	+43 10.3	.000	−0.80	0.80	180.0
120	Lalande 19229	8	43 28	+14 13.8	+ .023	−0.76	0.83	156.6
121	Weisse-Bessel IX. 954	9	46 10	−11 49.3	+ .085	−1.50	1.95	140.2
122	20 *Leonis minoris*	5	9 55 15	+32 24.9	− .042	−0.44	0.69	230.3
123	Groombridge 1618	6.5	10 5 15	+49 57.6	− .140	−0.52	1.45	248.9
124	Weisse-Bessel X. 234	9	14 11	+20 22.4	− .036	0.00	0.51	270.0
125	Groombridge 1646	6	21 54	+49 19.1	+ .011	−0.89	0.90	173.0
126	Weisse-Bessel X. 520	6	31 34	−11 41.6	+ .020	−0.68	0.74	156.6
127	Lalande 20881	8	46 7	+20 49.2	− .018	−0.43	0.50	210.2
128	Lalande 22008–10	8.5	50 52	+28 16.6	− .036	−0.13	0.50	254.8
129	*α Crateris*	4	54 54	−17 46.0	− .034	+0.14	0.50	286.3
130	Lalande 21185	7.5	10 57 53	+36 38.4	− .044	−1.74	1.77	186.4
131	Lalande 21258	8.5	11 0 31	+14 2.1	− .104	+0.35	1.47	282.8
132	Lalande 21368	8.5	5 35	+30 59.7	+ .042	−0.20	0.58	110.3
133	*ξ Ursae Majoris*	4	12 51	+32 5.5	− .037	−0.57	0.74	219.5
134	Piazzi XI. 32	7.5	13 12	− 4 31.0	+ .052	−0.15	0.79	100.9
135	Oeltz.-Argel. 11677	9	14 50	+66 23.3	− .503	+0.24	3.03	274.5
136	83 *Leonis*	6.5	21 42	+ 3 33.5	− .049	+0.17	0.75	283.1
137	Bradley 1584	6	29 38	−32 18.1	− .053	+0.84	1.08	321.0
138	Groombridge 1812	7.5	33 29	+45 39.7	− .060	+0.03	0.63	272.7
139	Groombridge 1822	8	40 18	+48 13.8	− .061	−0.28	0.66	245.0
140	Lacaille 4887	6	41 45	−39 57.4	− .133	+0.39	1.58	284.3
141	*β Leonis*	2	43 58	+15 7.9	− .036	−0.10	0.53	259.1
142	*β Virginis*	3.5	45 29	+ 2 19.7	+ .048	−0.26	0.77	109.9
143	Groombridge 1830	6	47 13	+38 26.2	+ .344	−5.80	7.06	145.3
144	Lacaille 4955	7	52 59	−27 8.0	− .074	−0.70	1.21	234.8
145	Lalande 22585	6	55 36	− 9 52.6	+ .003	−0.50	0.50	175.4
146	Piazzi XI. 218	7	57 25	+43 30.3	− .034	−0.56	0.67	213.5
147	Lalande 22667	9	11 58 58	+ 3 54.8	+ .004	−0.55	0.55	173.8
148	Lalande 22701	8.5	12 0 9	− 0 57.3	− .034	0.00	0.51	270.0
149	Weisse-Bessel XII. 69	8	7 25	− 2 32.4	− .040	+0.41	0.73	304.4
150	Lalande 22908	7	8 7	+11 23.6	+ .002	−0.59	0.59	177.1
151	Lalande 22954–68	6	10 2	− 9 43.7	+ .005	−1.03	1.03	176.1
152	Lacaille 5123	6	17 51	−67 5.1	− .136	+0.16	0.82	281.3
153	Lalande 23361	8.5	21 37	− 2 45.9	− .020	−0.62	0.69	205.8
154	8 *Canum venaticorum*	4.5	29 0	+41 52.0	− .065	+0.28	0.77	291.1
155	*η Virginis*	3	36 36	− 0 54.1	− .038	+0.02	0.57	272.0
156	33 *Virginis*	6	41 18	+10 5.9	+ .018	−0.45	0.52	149.4
157	Lalande 23947	8	44 39	+ 1 45.1	− .002	−0.68	0.68	182.5
158	Lalande 23995	8	47 56	−17 57.4	+ .022	−0.83	0.89	159.3
159	*δ Virginis*	3	50 34	+ 3 56.5	− .034	−0.05	0.50	264.4
160	Lalande 24168	7.5	12 53 54	− 9 18.0	−0.054	+0.17	0.82	282.0

No	Name	Mag.	R.A. 1900.0	Decl. 1900.0	Proper motion in R.A.	Decl.	Gr. Cir.	Pos.-Angle
			h m s	° '	s	"	"	
161	Oeltz.-Argel. 12585	8.5	12 56 5	—26 49.8	—0.035	—0.27	0.54	240.1
162	Weisse-Bessel XII, 920	8.5	12 56 10	— 7 53.9	— .035	—0.13	0.54	256.0
163	Lalande 24414–6	7	13 3 17	+ 5 45.5	+ .004	—0.72	0.72	175.2
164	Lalande 24504	8	6 25	+10 9.0	— .033	+0.25	0.54	297.5
165	43 *Comae*	4	7 12	+28 23.1	— .060	+0.90	1.20	318.7
166	61 *Virginis*	5	13 10	—17 45.3	— .076	—1.06	1.51	225.5
167	Weisse-Bessel XIII, 211	9	14 55	+35 39.4	+ .033	—0.83	0.92	151.3
168	Weisse-Bessel XIII, 216	8.5	15 43	+ 1 39.1	— .036	+0.22	0.58	292.2
169	70 *Virginis*	5	23 32	+14 18.8	— .018	—0.58	0.64	204.2
170	Piazzi XIII, 114	7.5	26 36	— 1 18.6	— .059	+0.23	0.91	284.7
171	*i Centauri*	4.5	40 0	—32 32.3	— .038	—0.16	0.51	251.6
172	Lalande 25372	8.5	40 40	+15 26.0	+ .125	—1.47	2.32	129.2
173	Piazzi XIII, 194	7	42 0	+ 6 51.2	— .032	—0.13	0.50	254.8
174	Lacaille 5710	6	13 45 50	—23 53.2	— .042	—0.35	0.68	238.9
175	*θ Centauri*	2.5	14 0 48	—35 52.7	— .045	—0.55	0.78	225.0
176	*α Bootis*	1	11 6	+19 42.2	— .080	—1.98	2.28	209.6
177	Lalande 26196	7.5	14 25	— 4 41.3	— .043	—0.12	0.65	259.4
178	Lalande 26289	6	18 8	+ 1 42.6	+ .015	—0.50	0.55	156.3
179	Mayer 576	6.5	31 40	—11 52.8	— .060	+0.36	0.96	292.0
180	*α Centauri*, m.	1	32 48	—60 25.4	— .484	+0.76	3.68	281.9
181	Weisse-Bessel XIV, 810	9	45 29	+ 7 13.8	— .042	—0.07	0.62	263.6
182	Lalande 27026, 7	8	46 0	—23 52.8	— .066	—0.48	1.02	241.9
183	Piazzi XIV, 212	6	51 37	—20 57.9	+ .072	—1.80	2.06	150.7
184	Fedorenko 2514	7.5	52 21	+54 4.3	— .110	+0.48	1.08	296.3
185	Lalande 27274	9	54 9	—21 36.0	— .042	—0.54	0.80	227.6
186	Weisse-Bessel XIV, 989	9	14 55 18	—10 13.5	.000	—0.54	0.54	180.0
187	Lalande 27531–3	8	15 2 53	— 7 31.0	— .011	—0.47	0.50	198.8
188	Bonn Beobb. VI. +25° 2874	9	3 8	+25 18.4	— .060	+0.44	0.92	298.5
189	Oeltz.-Argel. 14318, 9	9	4 41	—15 59.1	— .067	—3.61	3.76	194.8
190	Oeltz.-Argel. 14320–2	9	4 45	—15 51.1	— .066	—3.63	3.75	194.7
191	Lalande 27742	7.5	8 15	+19 39.2	— .043	+0.30	0.68	296.2
192	Lalande 27744	7	8 50	— 0 57.9	— .085	—0.53	1.38	247.4
193	5 *Serpentis*	5	14 12	+ 2 8.6	+ .024	—0.54	0.65	146.3
194	Lalande 27958	8	14 15	+26 3.5	— .037	—0.11	0.51	257.6
195	Weisse-Bessel XV, 268	8.5	17 40	+ 1 47.2	— .027	—0.33	0.52	230.5
196	Weisse-Bessel XV, 720	7	32 29	+10 7.9	— .033	+0.07	0.50	278.1
197	Lalande 28607	7	37 12	—10 36.4	— .076	—0.34	1.18	253.3
198	Lacaille 6521	6.5	40 59	—37 36.0	— .043	—0.29	0.59	240.4
199	39 *Serpentis*	6	48 33	+13 30.6	— .012	—0.58	0.61	197.2
200	χ *Herculis*	4.5	49 13	+42 43.9	+ .039	+0.61	0.75	35.2
201	*γ Serpentis*	3.5	51 50	+15 59.3	+ .019	—1.29	1.32	168.2
202	49 *Librae*	6	54 43	—16 14.3	— .046	—0.39	0.77	239.4
203	*ρ Coronae Borealis*	5.5	15 57 13	+33 36.3	— .016	—0.79	0.81	194.2
204	Lalande 29330	8.5	16 1 12	+10 57.4	— .033	—0.12	0.50	256.2
205	Groombridge 2305	7	1 30	+39 25.6	— .048	+0.05	0.55	275.2
206	Lalande 29439	8.5	2 54	+38 54.9	+ .018	—0.56	0.60	159.4
207	Lalande 29437, 8	6	4 16	+ 6 39.8	+ .016	—0.75	0.79	162.3
208	18 *Scorpii*	6	10 11	— 8 6.3	+ .014	—0.51	0.55	157.7
209	Weisse-Bessel XVI, 400	9	23 36	+ 3 29.4	.000	—0.51	0.51	180.0
210	Lalande 30044, 5	7.5	25 33	+ 4 26.1	— .030	—1.39	1.46	197.9
211	*ζ Herculis*	2.5	37 31	+31 47.0	— .036	+0.41	0.62	311.7
212	*ε Scorpii*	3	43 41	—34 6.7	— .050	—0.28	0.68	245.7
213	Lalande 30694	7.5	47 56	+ 0 10.9	— .049	—1.49	1.66	206.1
214	Weisse-Bessel XVI, 906	9	50 8	— 8 9.1	— .063	—0.87	1.27	226.8
215	Lalande 31132	6.5	59 47	+47 11.9	+ .013	+0.82	0.83	9.0
216	Lalande 31055	7.5	16 59 51	— 4 53.8	— .062	—1.15	1.48	218.9
217	36 *A Ophiuchi*	5	17 9 12	—26 27.4	— .039	—1.18	1.29	203.8
218	Bradley 2179	7	10 4	—26 24.1	— .038	—1.14	1.25	204.1
219	Lacaille 7215	7.5	12 9	—34 52.7	+ .096	—0.21	1.20	100.1
220	72 *ω Herculis*	5.5	16 55	+32 35.8	+ .010	—1.05	1.06	172.9
221	Weisse-Bessel XVII, 322	7.5	17 20 47	+ 2 14.0	—0.040	—1.22	1.36	206.2

No.	Name	Mag.	R.A. 1900.0	Decl. 1900.0	Proper motion in R.A.	Proper motion in Decl.	Gr. C.	Pos. Angle
222	Fedorenko 2895	7	17 25 19	+67 23.5	—0.091	+0.03	0.52	27[illegible]
223	Weisse-Bessel XVII, 514	8.5	29 53	+ 6 4.2	— .030	+0.36	0.58	308.7
224	26 *Draconis*	5.5	33 57	+61 57.1	+ .035	—0.50	0.56	153.4
225	Oeltz.-Argel. 17415.6	9	37 0	+68 25.8	— .069	—1.25	1.30	[illegible]
226	*μ Herculis*	3.5	17 42 33	+27 46.7	— .024	—0.74	0.81	205.4
227	70 *Ophiuchi*	4.5	18 0 24	+ 2 31.1	+ .017	—1.12	1.15	167.4
228	*μ Serpentis*	3	16 8	— 2 55.5	— .040	—0.68	0.91	221.4
229	*χ Draconis*	4	22 52	+72 41.4	+ .113	—0.37	0.63	125.9
230	P.M. 2164	8	41 40	+59 28.7	— .171	+1.87	2.28	325.0
231	Lamont 18180	9	18 53 7	+ 5 48.5	— .016	—1.22	1.24	191.1
232	Lamont 18816	9	19 2 11	+ 7 28.9	— .018	—0.75	0.80	199.8
233	Oeltz.-Argel. 19156-8	8.5	3 43	—21 37.2	— .015	—0.45	0.50	205.0
234	Groombridge 2789	6.5	9 30	+49 40.0	— .014	+0.61	0.62	348.0
235	31 *b Aquilae*	5.5	20 12	+11 43.8	+ .049	+0.63	0.96	48.8
236	Bradley 2459	6	21 17	+24 43.9	— .015	—0.63	0.66	197.6
237	Lacaille 8139	7.5	26 26	—28 12.7	+ .002	—0.76	0.76	177.7
238	Groombridge 2875	6.5	29 28	+58 23.0	— .066	—0.40	0.66	232.6
239	*σ Draconis*	5.5	32 33	+69 29.5	+ .100	—1.76	1.83	163.8
240	*α Aquilae*	1.5	45 54	+ 8 36.2	+ .035	+0.38	0.64	53.8
241	Lalande 38100	6.5	54 21	—10 13.2	— .021	—0.41	0.51	217.1
242	Lacaille 8267	6	55 34	—67 34.9	+ .186	—0.67	1.25	122.3
243	Lalande 38287	7.5	58 0	+15 19.7	— .013	—0.57	0.60	198.1
244	*δ Pavonis*	3.5	58 55	—66 26.2	+ .193	—1.18	1.65	135.5
245	Lalande 38380	6	59 31	+29 37.8	+ .052	—0.52	0.85	127.4
246	15 *Sagittae*	6	59 37	+16 47.9	— .028	—0.42	0.58	[illegible]
247	Lalande 38383	7.5	19 59 41	+23 5.0	— .071	—0.94	1.39	227.4
248	Lacaille 8362	6	20 4 38	—36 21.2	+ .037	—1.64	1.70	164.7
249	Piazzi XX, 23	7.5	6 34	+15 52.8	— .029	+0.36	0.55	310.6
250	Lacaille 8381	5.5	9 3	—27 19.9	+ .094	—0.24	1.28	100.8
251	Groombridge 3150	6.5	16 32	+66 31.9	+ .080	+0.31	0.57	57.2
252	Oeltz.-Argel. 20452	8.5	17 42	—21 39.7	+ .037	—1.10	1.22	154.7
253	*φ² Pavonis*	5	33 46	—60 53.0	+ .012	—0.54	[illegible]	170.1
254	Lacaille 8522	6.5	34 15	—21 8.4	+ .034	+0.41	0.62	48.9
255	Lalande 39866	8	34 33	+ 4 37.0	+ .057	+0.05	0.85	86.6
256	Fedorenko 3562-3	7.5	38 12	+75 13.9	+ .091	+0.51	0.64	[illegible]
257	*η Cephei*	3.5	43 15	+61 27.0	+ .012	+0.81	0.82	6.3
258	Lacaille 8620	6	51 3	—14 29.2	— .070	—0.99	1.12	208.1
259	Fedorenko 3638	7.5	52 22	+71 23.1	+ .106	+0.55	0.70	28.0
260	Lacaille 8625	6	58 54	—73 33.9	+ .108	—0.38	0.60	129.6
261	Weisse-Bessel XX, 1454	7.5	20 59 6	+ 2 36.5	— .025	—0.41	0.55	222.0
262	Lalande 40814	8.5	21 0 23	+ 6 41.2	+ .002	—0.57	0.57	177.0
263	61 *Cygni*, pr.	6	2 25	+38 15.4	+ .344	+3.23	5.18	51.4
264	Weisse-Bessel XXI, 97	7.5	7 21	+17 20.6	— .009	—0.90	0.91	188.2
265	Lacaille 8733	6.5	10 47	—61 15.5	+ .073	—0.44	0.67	130.7
266	Lacaille 8760	7.5	11 24	—39 15.3	— .280	—1.22	3.46	249.1
267	Lacaille 8777	7	13 59	—26 15.9	— .043	—0.36	0.67	237.7
268	Oeltz.-Argel. 21308	9	14 36	—20 15.3	— .012	—0.78	0.80	192.3
269	*γ Pavonis*	4.5	18 11	—65 19.1	+ .013	+0.80	0.80	5.7
270	Weisse-Bessel XXI, 502	9	24 30	—12 56.1	+ .070	—0.28	1.06	105.3
271	Lalande 42883-5	7	51 45	+29 20.7	— .029	—0.41	0.56	222.8
272	*ε Indi*	4	21 55 43	—57 11.8	+ .479	—2.65	4.71	123.9
273	Groombridge 3689	8	22 3 5	+52 39.1	— .055	—0.35	0.61	235.0
274	Lacaille 9061	6.5	8 32	—41 51.3	+ .050	—0.73	0.92	142.5
275	Lacaille 9076	5.5	11 12	—54 6.5	+ .049	—0.67	0.80	147.3
276	Lalande 43492	7	12 15	+12 23.8	+ .057	+0.09	0.84	83.9
277	*ν Indi*	6	16 2	—72 11.5	+ .280	—0.71	1.45	120.6
278	Lamont 31343	9	33 52	+ 2 0.1	+ .036	—0.09	0.55	99.5
279	*ζ Pegasi*	4.5	41 42	+11 39.6	+ .013	—0.51	0.54	159.6
280	*σ Pegasi*	5	47 20	+ 9 18.2	+ .034	+0.04	0.50	85.4
281	Lalande 44964	7.5	55 0	—23 3.8	— .067	+0.01	0.92	270.4
282	Lalande 45028	8	22 56 39	— 4 22.9	+ .030	—0.29	0.54	122.8

No.	Name	Mag.	R.A. 1900.0	Decl. 1900.0	Proper motion in R.A.	Proper motion in Decl.	Gr. Cir.	Pos.-Angle
			h m s	° ′	s	″	″	
283	Lacaille 9352	7.5	22 59 25	−36 25.8	+0.573	+1.15	7.00	80.5
284	Fedorenko 1371	7.5	23 1 10	+67 52.4	+ .102	+0.15	0.60	75.5
285	Lalande 45292-1	8.5	3 58	− 2 18.0	+ .039	−0.13	0.59	102.6
286	Lacaille 9396	5	7 57	−63 13.9	+ .073	−0.10	0.63	129.2
287	Bradley 3077	6	8 28	+56 37.0	+ .250	+0.28	2.08	82.3
288	Lalande 45455	7.5	8 52	− 9 28.1	+ .037	−0.08	0.56	98.3
289	Lalande 45456	8	8 52	− 9 28.5	+ .037	−0.05	0.55	95.2
290	Weisse-Bessel XXIII. 175 .	8	11 54	−14 21.9	− .035	−1.21	1.31	202.9
291	*ζ Piscium*	4	11 59	+ 2 11.1	+ .049	+0.02	0.73	88.4
292	Lalande 45755	7.5	16 16	+13 32.6	+ .058	+0.22	0.67	70.8
293	Lacaille 9537	6	33 12	−73 15.3	+ .027	−0.73	0.71	170.7
294	*ι Piscium*	4.5	34 48	+ 5 7.0	+ .023	−0.11	0.56	111.5
295	Piazzi XXIII, 164	7	38 32	+57 30.7	+ .047	+0.49	0.62	37.8
296	Lacaille 9585	7	41 15	−42 6.8	+ .010	−0.85	0.86	172.6
297	Lalande 46650	8.5	43 59	+ 1 52.3	+ .065	−1.00	1.39	135.9
298	Oeltz.-Argel. 23166, 7 . . .	7.5	51 17	−20 35.0	+ .010	−0.28	0.63	116.6
299	85 *Pegasi*	6	56 57	+26 33.2	+ .062	−0.99	1.29	110.1
300	Arg. Gen. Catal. 32416 . .	8.5	59 31	−37 51.0	+ .485	−2.58	6.29	114.2
301	Piazzi XXIII, 267	7	23 59 39	+34 6.0	+0.062	+0.08	0.78	84.1

Cincinnati Observatory, 1892 *May* 7.

OBSERVATIONS OF COMETS,

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 9.6-INCH EQUATORIAL,

BY PROF. E. FRISBY.

[Communicated by the Superintendent.]

1892 Washington M.T.	⁎	No. Comp.	☄ − ⁎ Δα	☄ − ⁎ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
				COMET *b* 1892 (Periodic of WINNECKE).				
d h m s			m s	′ ″	h m s	° ′ ″		
May 25 10 0 10.1	1	15 , 3	−3 10.01	+10 0.1	10 0 26.87	+43 57 45.9	9.684	9.923
28 9 17 10.8	2	15 , 3	+2 38.81	+11 45.6	10 56 53.13	+43 41 37.8	9.626	9.964
June 1 10 15 54.1	3	15 , 3	−3 0.06	− 2 57.1	10 51 34.81	+43 16 54.3	9.747	0.260
				COMET *a* 1892 (SWIFT).				
May 28 12 0 58.4	4	15 , 3	−1 15.72	−12 42.5	23 46 13.45	+36 8 29.4	*n*9.731	0.764

Mean Places for 1892.0 of Comparison-Stars.

⁎	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	11 3 35.76	+1.12	+43 47 35.7	+10.1	Paris 13622
2	10 54 13.31	+1.01	+43 29 41.8	+10.4	Paris 13462
3	10 54 33.92	+0.95	+43 19 40.8	+10.6	Paris 13466
4	23 17 29.79	−0.62	+36 21 22.9	−11.0	Römker 11707

THE DOUBLE STAR NEAR *β CYGNI.*

BY S. W. BURNHAM.

The double star mentioned by Prof. JACOBY (*A.J.* 265), as being shown on the RUTHERFURD photographic plates of stars in the vicinity of *β Cygni*, is one of the oldest known pairs, having been observed by HERSCHEL something more than a century ago. It was subsequently included in the catalogues of SOUTH and STRUVE, and carefully measured by the latter observer. As a double star it is known as H II. 99 = S 718 = Σ 2539. While photography has its uses for general mapping and cataloguing purposes, it is not likely, for the present, at least, to have any application in observations of real double stars. All the interesting physical systems are much too close to be shown on a photographic plate with any telescope. For distant stars, beyond the ordinary range of the micrometer, the photographic method may be very useful. The apparent change of the components of the star in question, as shown by the plates, is not real. This pair is much too wide to have any relative motion in such an interval which would appear on the

plate. As a matter of fact, there has been no change at all in these stars since the first accurate measures.

This star is really triple. In 1878, when observing with the Chicago 18½-inch, I found a third star, a little nearer than the HERSCHEL companion. This is a very faint companion, and of course entirely beyond the reach of any photographic experiment, however prolonged the exposure. It is not probable that these stars have any physical relation.

The following are all the measures of *AB*:

A AND *B* (= 3652).

1878.97	328.6	4.33	. . 13	BURNHAM 2*n*
1892.38	325.3	5.17	. . 13.3	BURNHAM 3*n*

The apparent change here is probably not real. This is a faint star with the 36-inch [illegible] cult with the instrument used in 1878.

A few of the measures of *AC* [illegible] fixity of these stars.

A AND *C* (= Σ 27[illegible]).

1830.69	5.2	5.56	7.9 . . 9.7	[illegible]
1867.03	2.4	5.58	7.5 . . 9.6	D[illegible]
1878.73	3.8	5.60	8.0 . . 10.0	B[illegible]
1887.78	2.8	5.34	7.5 . . 9.5	T[illegible]
1892.38	3.5	5.40	8.0 . . 8.7	B[illegible]

This whole region of *Cygnus* is rich in [illegible] T. variable. *Y Cygni*, has a very minute com[illegible].

Mt. Hamilton, 1892 *May* 21.

OBSERVATIONS OF SHORT-PERIOD VARIABLES, MADE IN 1891.

BY PAUL S. YENDELL.

7149 *S Sagittae*.

From 1891 May 28 to Dec. 27, I observed *S Sagittae* on ninety-four evenings: from these observations are deduced the following times of maxima and minima.

	MAXIMA	W		MINIMA	W
1891	June 8.4	4	1891	July 8.3	2
	July 4.5	3		16.4	3)
	11.7	4)		25.0	4
	21.3	3		Aug. 19.3	2)
	28.6	1		Sept. 3.4	4
	Aug. 21.66	4		30.3	2
	Sept. 7.6	3		Nov. 19.3	3
	16.7	2)			
	Oct. 2.87	2			
	22.3	3			
	Nov. 6.7	4			
	23.1	2			

7437 *X Cygni*.

My observations of this star for the past season were begun 1891 May 13, and continued until 1892 Jan. 7, accumulating to the number of one hundred and twenty: from these observations ten maxima and twelve minima have been deduced by the usual graphic method, and, with the observed maximum and minimum lights, on a scale published in Vol. 10 of this Journal, p. 173, are as follows:

E	MAXIMA	W	LT.	MINIMA	W	LT.
101	1891 Jure 10.2	4	13.5	June 5.2	4	7.2
106	July 12.0	4	12.0)	July 6.8	4	6.2
107	29.8	4	12.5	23.3	4	5.2
108				Aug. 10.0	4	7.2
109	Sept. 1.4	3		24.3	4	6.2
110	17.8	4	11.4)	Sept. 11.2	4	5.2)
111	Oct. 3.4	5	13.5	26.8	5	4.0
112	19.6	4	10.5)	Oct. 11.9	4	4.0)
113	Nov. 5.2	4	10.5	28.8	5	3.5
114	20.7	3	10.5	Nov. 15.3	4	4.0)
115	Dec. 7.5	2	10.5	30.25	4	3.0
116				Dec. 18.75	3	3.5

The observed light-values appear to confirm the presence of a periodical fluctuation in the star's mean light, showing a minimum at Epoch 115.

7483 *T Vulpeculae*.

Ninety-eight observations of this star were secured during the past season, from 1891 May 28 to Dec. 31. By the use of a mean light-curve, formed from more than three hundred observations made during the past four years, and to which reference will again be made, I have deduced the following times of maxima and minima: the weights indicate the number of observations from which each time was deduced.

	MAXIMA	W		MINIMA	W
Ep.458	1891 May 27.72	1	Ep.460	1891 June 4.62	1
467	July 6.40	1	461	8.74	1
468	11.79	2)	465	25.41	1
471	23.72	1)	467	July 4.63	2
473	Aug. 2.41	2	468	9.89	2
474	6.37	1	471	22.38	1)
475	10.80	1	472	26.88	2
477	20.80	1)	473	31.36	1
478	24.88	1	476	Aug. 13.41	1)
479	28.59	1	478	22.56	1
480	Sept. 2.21	2	481	Sept. 5.45	1
481	7.15	1	485	22.54	2
482	11.27	1)	486	26.89	2
483	15.20	2)	487	Oct. 1.27	2
484	19.87	2)	491	19.40	1)
485	24.79	1	492	24.24	2
486	28.30	1	493	28.71	1
487	Oct. 3.51	2	495	Nov. 6.56	1
490	16.02	1	497	15.94	1)
491	20.75	2)	Ep.504	1891 Dec. 16.32	1)
492	25.55	1			
493	30.54	2			
494	Nov. 3.44	2			
495	7.50	2			
497	17.26	1)			
498	20.75	1			
499	24.97	2			
500	30.00	2			
501	Dec. 4.17	2			
502	9.05	2)			
503	13.26	1)			
504	17.86	1)			
506	26.56	1			
Ep.507	1891 Dec. 30.84	2			

The comparison-stars used in these observations are some of Dr. CHANDLER'S (*A.J.* Vol. VII, p. 62) and the scale from the four years' observations is as follows:

$$b = 9^{st}.3$$
$$c = 1.8$$
$$f = 0.0$$

All comparisons in which a (= *F* 32 *Vulpeculae*) were used have been discarded, the star having proved variable.

Dorchester, Mass., 1892 *May* 16.

The mean curve deduced agrees closely with SAWYER'S (*A.J.* Vol. VIII, p. 6): the readings from it are as follows:

d	st	d	st	d	st
—1.297	1.91	+0.25	8.73	+2.00	2.96
1.25	1.95	.50	7.67	2.25	2.66
1.00	2.50	.75	6.66	2.50	2.37
.75	1.20	1.00	5.78	2.75	2.12
.50	6.10	1.25	4.93	3.00	1.96
—0.25	8.16	1.50	4.13	+3.11	1.94
±0.00	9.78	+1.75	3.41		

LEWIS MORRIS RUTHERFURD.

This honored and beloved man, the initiator of astronomical photography, both as regards its practical methods, and its earliest achievements, died on the thirtieth of May, at his ancestral estate in Tranquillity, New Jersey, in his 76th year, having been born at Morrisania, N. J., 1816 Nov. 25.

His grandfather, JOHN RUTHERFURD, was a nephew of Major General WILLIAM ALEXANDER, known in American history as the Earl of Stirling, who bore a distinguished part in the battles of the Brandywine and Germantown, commanded the left wing of the American army at Monmouth, and attained some note as a mathematician and astronomer. JOHN RUTHERFURD was Senator of the United States from 1791 till 1798, and became the last survivor of the Senators who served during the administration of President WASHINGTON.

The great-grandfather whose name he bore, was a signer of the Declaration of Independence, and a grandson of LEWIS MORRIS, first Governor of New Jersey.

Mr. RUTHERFURD devoted himself at first to the profession of the law, — but his tastes were strongly astronomical, and these together with his exceptional mechanical ability, led him to abandon the professional career originally undertaken, and to devote himself to scientific pursuits. The ample resources at his command rendered this comparatively easy; and as early as 1848 he constructed an astronomical observatory at his residence in the heart of the city of New York. This he equipped with a transit-instrument, an 11¼-inch refractor, constructed under his personal direction by FITZ, and corrected by new methods, discovered by that optician.

Here with a singular abstinence from all ostentation, he quietly pursued his studies of astronomical photography and stellar light; reserving all announcements of his results until they were ripe for publication. In January 1863 he published his first paper upon the spectra of the celestial bodies, and gave the first classification of stars by their spectra. In 1865 he described his photographic object-glass, designed for the use of those rays only which acted upon the sensitive photographic film, pointed out the practical methods for its construction, and illustrated the results thus attainable by his wonderfully sharp and beautiful photographs of the moon. Even now, these suffer little by comparison with subsequent ones, obtained with the advantage of the vast recent progress in photographic art, and the use of lenses of ten times the area. In opposition to then dominant authority he demonstrated the stability, upon the glass, of the collodion film when properly albuminized. He devised and constructed accurate micrometers for measuring the impressions of stellar clusters, which he had been the first to obtain, and a large number of measurements were made under his direction.

For studying stellar spectra he constructed ruled gratings which surpassed the famed masterpieces of NOBERT, and which themselves remain unsurpassed, except by those which have been obtained by ROWLAND following in the same path.

About 1868 he introduced the photographic corrector, an additional lens applicable to visual object-glasses, to adapt them for the most effective photographic use.

During all these years he was struggling with disease which unfitted him alike for sedentary pursuits and for atmospheric exposure; yet, with wasting strength, he heroically persisted in his scientific efforts, and, when he could no longer work in person, he supervised the measurements of a large number of the photographs of stellar clusters, which he had taken.

In 1884 he presented all his astronomical instruments, apparatus, and completed measurements, to Columbia College, N.Y., where the computation of his results is now being prosecuted by Mr. JACOBY, under the direction of Prof. REES. The resultant determinations for the Pleiades have very recently been published, and those for other clusters are already far advanced.

Mr. RUTHERFURD was of an exceptionally amiable and generous disposition, helpful to others, and tolerant of their failings. His intellectual diffidence and almost shrinking modesty were as notable as were his boldness of invention, ingenuity of device, and persistence in following up his ideas, under very trying circumstances. The moral influence of his example, among his co-workers, was quite as beneficent as the scientific stimulus exerted by the results he attained and partially published. To these qualities he added a calm and unprejudiced judgement, an admirable power of statement, and every instinct of a gentleman.

CORRIGENDUM.

No. 266, p. 12, col. 1, line 7, *for* 46.0 *put* 4.60.

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No. 269.

VOL. XII. BOSTON, 1892 JUNE 22. NO. 5.

NOTES ON DOUBLE STARS (II),

BY A. HALL.

Σ1216.

The motion of this close binary has been almost wholly in the angle, and a mean distance, 0″.44, has been used in computing the coordinates.

$$s \sin p = +0''.249 - (0''.0066)\,[t-1860.0] - (0''.000056)\,[t-1860.0]^2$$

$$s \cos p = -0''.369 - (0''.0043)\,[t-1860.0] + (0''.000067)\,[t-1860.0]^2$$

Date	p	s	x	y	C − O	
					Δx	Δy
	°	″	″	″	″	″
1831.24	115.30	0.452	+0.398	−0.188	−0.005	−0.002
1851.28	139.49	0.490	0.286	0.335	+0.016	+0.008
1866.55	151.45	. .	0.210	0.387	−0.006	−0.007
1880.92	166.57	0.357	+0.102	0.428	−0.016	−0.002
1891.26	183.05	0.462	−0.023	−0.439	+0.011	+0.001

Σ1338.

This star is probably binary, but the motion can be nearly represented by a right line.

$$s \sin p = +1''.062 - (0''.0163)\,[t-1860.0]$$

$$s \cos p = -1''.202 - (0''.0090)\,[t-1860.0]$$

Date	p	s	x	y	C − O	
					Δx	Δy
		″	″	″	″	
1829.53	121.29	1.762	+1.506	−0.915	+0.053	−0.013
1841.85	126.74	1.730	1.386	1.035	−0.028	−0.004
1849.14	131.95	1.680	1.219	1.123	−0.010	+0.019
1864.86	141.71	1.566	0.970	1.229	+0.013	−0.017
1876.29	151.72	1.630	0.772	1.435	+0.021	+0.086
1888.28	158.16	1.540	+0.573	−1.129	+0.028	−0.028

ORBIT OF ω *Leonis* = Σ 1356.

The apparent distance of this star varies from a third of a second to one second of arc, and it is therefore one of the closest binaries of which we have observations from the time of W. HERSCHEL; and since that time it has described nearly a complete revolution. The relative accidental and personal errors of observation are very great for the small distances, but the observations of angle should be of a high order of accuracy, since an error of 5° in angle = 0″.05, at the average distance. I have, therefore, computed an orbit of this star from the angles only. The elements of DOBERCK, *Astr. Nach.*, No. 2095, were assumed, and an ephemeris was computed from 1782 to 1892. These elements are as follows:

$$
\begin{aligned}
☊ &= 118^\circ\ 16' \\
\gamma &= 64\ \ \ 5 \\
\lambda &= 121\ \ \ 1 \\
e &= 0.5360 \\
P &= 110.82 \text{ years.} \\
T &= 1841.81
\end{aligned}
$$

I have adopted the notation of ENCKE, except that γ denotes the inclination between the planes of the real and apparent orbits, and λ is the distance from the node to the periastron. By aid of the ephemeris the following normals and residuals were formed, the angles being reduced to the epoch 1841.81.

Date	p	C − O	Wt.
	°		
1782.86	111.11	−3.04	1
1803.09	131.02	−0.65	1
1825.21	154.00	−3.71	2
1833.38	169.00	−0.49	4
1844.10	314.72	−0.52	1
1852.52	343.86	+2.55	1
1858.00	2.52	+0.61	1
1870.15	18.34	+0.58	1
1876.72	70.42	+0.72	1
1883.28	87.25	+1.78	4
1889.80	99.54	+2.51	1

The first two positions depend on the observations of HERSCHEL, and the third on those of W. STRUVE. For the other normals there are numerous observations, generally from eight to fifteen, and I have given them all the same convenient weight. The equation of condition is of the form

$$a\,\Delta☊ + b\,\Delta\gamma + c\,\Delta\lambda + d\,\Delta e + e\,\Delta M + f\,\Delta\mu + C - O = 0$$

The coefficients a, b, c, &c., are the partial derivatives of the angle with respect to the elements of the orbit, and have the following values:

$$a = +1$$

$$b = -\sin\gamma\tan(v+\lambda)\cos^2(p-☊)$$

$$c = \cos\gamma\frac{\cos^2(p-☊)}{\cos^2(v+\lambda)}$$

$$d = \frac{(2-e\cos E-e^2)\sin E}{(1-e\cos E)^2}\cdot c$$

$$e = \frac{\cos\varphi}{(1-e\cos E)^2}\cdot c$$

$$f = \frac{t-T}{10}\cdot e$$

v and E are the true and eccentric anomalies. The equations of condition, and the residuals after the solution, are as follows:

									Residuals
$+1.000\,\Delta☊$	$+1.011\,\Delta\gamma$	$+1.216\,\Delta\lambda$	$+0.152\,\Delta\varphi$	$+0.438\,\Delta M_0$	$-2.580\,\Delta n$	-3.04	$=$	0	$+0.07$
$+1.000$	$+0.617$	$+0.611$	-0.398	$+0.265$	-1.026	-0.65			$+0.29$
$+1.414$	$+0.035$	$+0.618$	-1.135	$+0.579$	-0.962	-5.29			-5.11
$+2.000$	-1.291	$+1.283$	-3.121	$+2.153$	-2.068	-0.98			$+1.51$
$+2.000$	$+0.991$	$+1.104$	$+1.536$	$+3.973$	$+0.910$	-1.04			-0.96
$+2.000$	-1.189	$+1.211$	$+2.798$	$+1.834$	$+1.965$	$+5.10$			$+2.82$
$+2.000$	-1.916	$+2.053$	$+3.838$	$+1.980$	$+3.206$	$+1.28$			-0.87
$+2.000$	-0.681	$+4.390$	$+4.708$	$+2.313$	$+6.626$	$+1.16$			-0.66
$+2.000$	$+0.880$	$+4.502$	$+3.494$	$+1.997$	$+6.970$	$+1.44$			-0.96
$+2.000$	$+1.804$	$+3.656$	$+1.854$	$+1.439$	$+5.969$	$+3.56$			$+1.44$
$+2.000$	$+2.068$	$+2.856$	$+0.753$	$+1.019$	$+5.036$	$+5.02$	$=$	0	$+1.36$

The solution of these equations by least-squares gives,

$$\Delta☊ = -1^\circ\ 40' \qquad \Delta\varphi = +0^\circ\ 8'$$

$$\Delta\gamma = +0\ \ 4 \qquad \Delta M_0 = +0\ 34$$

$$\Delta\lambda = +1\ 49 \qquad \Delta n = -0^\circ.126229$$

The probable error of a position of weight unity is ±1°.99; or ±0″.021, at the distance 0″.6. In order to find the mean distance, or semi-major axis of the orbit, I have computed it from the apparent distances measured by the observers who have most frequently observed this star. Their observations give the following results:

W. Struve	
$0.929\,a$ =	$0''.970$
0.600	0.515
0.537	0.447
$2.066\,a$ =	1.932

Dembowski	
$0.584\,a$ =	$0''.460$
0.593	0.440
0.611	0.415
0.623	0.438
$2.411\,a$ =	1.753

O. Struve		O. Struve	
$0.376\,a$ =	$0''.375$	$0.601\,a$ =	$0''.520$
0.432	0.483	0.588	0.600
0.476	0.440	0.581	0.625
0.520	0.450	0.573	0.560
0.551	0.535	0.553	0.520
0.578	0.428	0.514	0.550
0.595	0.430	0.547	0.580
0.611	0.487	0.554	0.570
0.620	0.463	0.559	0.520
0.614	0.470	0.570	0.590

$$11.046\,a = 10''.196$$

R. Engelmann	
$0.685\,a$ =	$0''.559$
0.703	0.620
0.722	0.658
0.711	0.719
0.761	0.727
$3.612\,a$ =	3.283

A. Hall	
$0.633\,a$ =	$0''.415$
0.651	0.462
0.670	0.480
0.687	0.490
0.706	0.617
0.724	0.550
0.779	0.535
0.798	0.664
0.817	0.668
0.836	0.642
0.853	0.748
0.874	0.748
$9.028\,a$ =	7.019

Hence we have the following values.

W. STRUVE	$a = 0''.935$	wt. = 1
O. STRUVE	$a = 0.923$	4
DEMBOWSKI	$a = 0.727$	1
ENGELMANN	$a = 0.909$	2
A. HALL	$a = 0.777$	3

The new elements therefore are,

$$☊ = 147^\circ\ 6'$$

$$\gamma = 61\ \ 9$$

$$\lambda = 122\ 53$$

$$e = 0.53789$$

$$P = 115.30 \text{ years}$$

$$T = 1841.99$$

$$a = 0''.864$$

The period is increased $4\frac{1}{2}$ years, and the other elements

are changed but little. From the corrected elements a new ephemeris was computed, and I have compared all the observed angles that I have found. The residuals are given in the following table in the sense C — O.

Date	Observer	Δp	Date	Observer	Δp
1782.87	W. Herschel	+ 0.7	1856.30	Winnecke	— 3.4
1803.09	"	— 0.7	1865.26	Dembowski	— 3.5
1825.21	W. Struve	— 3.9	1870.15	"	— 7.1
1832.25	"	+ 0.6	1871.16	"	— 3.4
1833.29	"	— 4.7	1872.21	"	— 0.8
1835.34	"	+ 5.6	1873.58	"	— 4.0
1836.28	"	+ 7.4	1875.25	"	— 0.8
1830.24	J. Herschel	+12.0	1876.16	"	— 2.6
1831.01	Dawes	— 5.4	1877.36	"	— 6.1
1842.27	"	— 2.9	1878.28	"	— 1.2
1843.18	"	+ 5.0	1865.67	R. Engelmann	+ 4.0
1854.23	"	+ 3 2	1882.23	"	+ 4.0
1832.11	Smyth	+ 3.6	1883.24	"	+ 0.7
1840.29	O. Struve	+16.1	1884.23	"	— 2.6
1842.31	"	— 4.4	1885.27	"	+ 0.4
1843.30	"	—11.8	1886.32	"	0.0
1844.29	"	— 7.6	1870.33	Düner	+ 8.0
1845.31	"	— 2.7	1871.31	"	— 2.4
1846 30	"	+ 0.5	1875.31	"	— 2.8
1847.33	"	— 1.4	1872.18	Wilson	—13.2
1848.32	"	— 1.0	1873.23	"	+ 0.4
1849.32	"	+ 2.2	1873.29	Gledhill	— 0.1
1850.96	"	+ 2.7	1876.20	"	+ 3.3
1852.66	"	— 5.4	1875.26	Schiaparelli	+ 1.2
1855.32	"	+ 3.8	1877.28	"	— 0.3
1857.28	"	+ 0.5	1879.31	"	— 0.2
1859.30	"	— 1.7	1881.33	"	— 2.6
1860.28	"	— 1.8	1882.36	"	— 5.7
1861.28	"	— 0.2	1883.31	"	— 4.2
1864.30	"	— 6.4	1884.30	"	— 2.4
1868.63	"	— 1.1	1885.31	"	— 2.7
1870.28	"	— 7.7	1876.28	Wilson Seabrooke	— 6.2
1872.31	"	— 5.3	1877.22	Doberck	— 4.1
1873.96	"	— 2.9	1878.95	A. Hall	+ 1.1
1846.28	Mädler	— 6.7	1880.26	"	— 2.2
1851.24	"	— 2.1	1881.31	"	— 2.6
1852.30	"	+ 3.4	1882.30	"	+ 0.2
1853.38	"	— 0.1	1883.31	"	— 1.3
1854.31	"	— 2.4	1884.32	"	— 4.4
1855.28	"	— 6.8	1887.30	"	— 0.8
1856.42	"	— 5.3	1888.29	"	— 1.5
1853.18	Jacob	+ 3.1	1889.29	"	— 1.3
1853.96	"	— 1.5	1890.32	"	— 1.1
1855.29	Secchi	— 7.5	1891.28	"	+ 0.6
1856.17	"	— 4.3	1892.30	"	+ 1.1
1857.36	"	— 5.5	1885.31	Tarrant	— 3.0
1858.35	"	+ 1.6	1888.21	"	— 0.7
1866.30	"	— 2.5	1890.27	Comstock	— 1.7
1857.29	Morton	+ 3.6	1891.05	Leavenworth	— 1.0
1855.34	Winnecke	—13.6			

Some of these residuals may appear large, but it should be remembered that the distance was small, and that the real error in the arc of a great circle is not large. Thus, in the case of the residual of 1840, +16°.1, the distance was only a third of a second, and this difference amounts to 0″.09. Perhaps I have given too much weight to the early observations of HERSCHEL, but these will be useful for some years to come.

ζ *Leonis* = Σ 1121.

The observations of this star since the time of HERSCHEL give an angular motion of 31°, but since STRUVE, only 11°. Though it is probable that this star is binary, the modern observations can be satisfied by a right line, and the orbits that have been computed must be very uncertain.

$$s \sin p = +2''.823 + (0''.01326)\,[t-1860.0] + (0''.0000336)\,[t-1860.0]^2$$

$$s \cos p = -1''.036 - (0''.01513)\,[t-1860.0] + (0''.0000060)\,[t-1860.0]^2$$

Date	p	s	x	y	C — O Δx	C — O Δy
1829.74	102.72	2.471	+2.410	—0.544	+0.043	—0.029
1833.96	104.27	2.533	2.455	0.624	+0.046	—0.011
1840.31	106.51	2.842	2.725	0.808	—0.170	+0.069
1847.45	107.75	2.780	2.648	0.848	+0.011	+0.003
1861.04	110.02	2.973	2.793	1.018	+0.011	—0.034
1869.90	111.61	3.155	2.933	1.163	+0.024	—0.022
1876.24	113.06	3.304	3.040	1.294	+0.007	+0.014
1884.79	113.86	3.502	+3.203	—1.117	—0.030	+0.010

Σ 1757.

In the case of this star the increase of distance and the slow motion in angle have caused doubt, but the following results indicate that it is a binary.

$$s \sin p = +1''.716 + (0''.02967)\,[t-1860.0] - (0''.000574)\,[t-1860.0]^2$$

$$s \cos p = -1''.158 - (0''.01311)\,[t-1860.0] - (0''.000119)\,[t-1860.0]^2$$

Date	p	s	x	y	C — O Δx	C — O Δy
1828.31	16.26	1.497	+0.419	+1.437	—0.022	+0.017
1831.58	25.44	1.599	0.687	1.444	+0.030	—0.030
1843.56	40.55	1.784	1.160	1.356	—0.031	—0.014
1853.63	50.87	1.849	1.434	1.167	+0.078	+0.070
1863.66	58.16	2.197	1.866	1.159	—0.046	—0.051
1880.45	68.79	2.370	2.209	0.857	—0.014	—0.017
1882.63	70.53	2.311	2.179	0.770	+0.011	+0.030
1888.41	72.61	2.332	+2.226	+0.696	+0.027	—0.006

Σ 1785.

The motion of this star also has been thought rectilinear, but my results show that it is binary, and we may soon expect a more rapid motion in angle. Although an easy pair to observe, the measures of distance by experienced observers are very discordant.

$$s \sin p = -0''.387 - (0''.01058)\,[t-1860.0] + (0''.000165)\,[t-1860.0]^2$$

$$s \cos p = -2''.962 + (0''.01320)\,[t-1860.0] + (0''.000991)\,[t-1860.0]^2$$

Date	p	s	x	y	C − O	
					Δx	Δy
		″		″	″	″
1830.12	164.35	3.487	+0.941	−3.358	+0.034	−0.009
1843.07	173.82	3.440	+0.370	3.420	−0.023	+0.011
1853.68	181.08	3.233	−0.061	3.232	−0.063	+0.037
1861.32	188.42	2.901	0.425	2.870	−0.016	−0.033
1872.76	202.93	2.407	0.938	2.217	+0.060	−0.033
1878.71	211.90	2.135	1.128	1.813	+0.039	+0.009
1881.91	218.93	1.988	1.249	1.546	+0.052	+0.006
1888.41	231.57	1.623	−1.322	−0.941	−0.085	+0.006

1892 *May* 31.

THEORETICAL PHOTOGRAPHIC MAGNITUDES OF THE NEW STAR IN *AURIGA*,

BY J. M. SCHAEBERLE.

The problem of determining the photographic magnitudes of the fixed stars has claimed the special attention of several observers: CHARLIER, PICKERING, PRITCHARD, SCHEINER and others. The present writer took up the subject in the summer of 1889. The preliminary results obtained will be found published in No. 4 of the *Publications of the Astronomical Society of the Pacific*. The method which I devised differs from all others in this particular: For any exposure-time the photographic magnitude of any star is expressed as a function of the equivalent theoretical aperture which a standard star (*Polaris*) would require to make the same impression on the plate in the same time.

In fact, the investigation led to a formula which may be said to be of a theoretically general character (when properly interpreted), applicable to a photographic telescope of any size, provided the constants peculiar to the particular instrument employed are first determined, or, better still, eliminated.

A peculiarity of this particular form of expression is the fact that having once assumed the photographic magnitude of the standard star, whose image is impressed upon the photographic plate, the theoretical photographic magnitude of any other star whose image is impressed upon the same plate is determined without reference to its visual magnitude.

If the spectrum of any given star is unknown, there is no known method of determining the photographic magnitude from the known visual magnitude. If this last statement is conceded to be true, it would seem to follow that photographic magnitudes should be determined independently of the visual determinations; for if the light-ratio is taken the same for the photographic and visual magnitudes, namely 2.5, the conditions which must be fulfilled are of a fixed character.*

To obtain a uniform system of photographic magnitudes, it is of course necessary to have the plates covered with an emulsion prepared according to a fixed formula. (In what follows I have assumed the emulsion to be invariable). Apparent deviations from a law deduced from observations made with a particular instrument can then be ascribed to instrumental differences.

In deducing a law for the determination of magnitudes from data depending upon the form of the images, considerable uncertainty will generally exist in deciding upon the proper boundaries of the stellar images; for the two extremes of magnitude this uncertainty in long exposure is greatest. Farther on I shall show how to reduce this uncertainty to a minimum.

If with a standard aperture $Q_0 (= 6$ inches) the diameter of the image of any star is d for an exposure time t, then the theoretical aperture Q which a standard star, as *Polaris*, requires to produce an equal impression on the plate in the same time t, can be determined by means of equation (1) which I deduced from observations on bright stars, using only SEED plates, sensitometer 26.

$$d = a + 0^{\text{in}}.0033(\log \frac{Q}{Q_0} + \frac{Q}{Q_0} \log t) \dagger \qquad (1)$$

The numerical value of a for the particular telescope used (a 6-inch DALLMEYER lens belonging to the U.S.N.O.) being $0^{\text{in}}.0055$. The constant $+0.0033$ probably depends largely upon the kind of dry-plate used.

With the arguments t and Q the computed theoretical values of d were tabulated to four decimal places. In using this table, which is not printed here, the measured value of d corresponding to a given t gives at once, by easy interpolation, the theoretical value of Q, or the theoretical magnitude m'; the relation between Q and m', for perfect telescopes, being expressed by the equation,

$$m' = 2.00 - \frac{\log \left(\frac{Q}{Q_0}\right)^2}{0.4} \qquad (2)$$

(See *Publications A.S.P.*, Vol. I, p. 61), *Polaris* being taken

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* See a paper by Professor HOLDEN in *Publications of the Astronomical Society of the Pacific*, Vol. I, p. 112, in which the general subject of determining photographic magnitudes is discussed.

† Our measuring engine, for a time used in this work, has its scales graduated to inches, which must serve as an excuse for using this unit of measure as a standard.

as the standard star having the photographic magnitude 2.00 (assumed).

In this table the range of m' is 15 magnitudes, namely, from $m' = -3.00$ to $m' = 12.00$, and for values of t in seconds from $(2)^0$ to $(2)^{16}$, or from 1^s to $18^h\ 12^m.3$.

This table is computed for $Q_0 = 6$ inches. If the aperture of the telescope is nQ_0, then for theoretically perfect telescopes the magnitude m'_n would be expressed by the equation

$$m'_n = 2 - \frac{\log\left(\frac{Q}{nQ_0}\right)^2}{0.4} \tag{3}$$

Hence with the aid of the table we should also be able to determine the theoretical photographic magnitude of a star photographed with an aperture nQ_0, by simply adding $5 \log n$ to the tabular m', corresponding to the observed arguments d (corrected) and t. In order to obtain some idea as to how far these theoretical relations can be relied upon in practical applications to telescopes in actual use, a most extreme case was selected.

Professor HOLDEN, aided by Professor CAMPBELL, made for me a series of exposures on *Polaris* with the 33-inch photographic objective of the great equatorial; the exposure times being respectively 1, 2, 4, 8, 16, 32, 64, 128 and 256 seconds. By subtraction, as in equation (6), we can get rid of the constant of the 33-inch lens. Formula (4) shows that whatever the constant term for a given telescope may be, the *growth* $d_2 - d_1$ of the image during the interval of time $(t_2 - t_1)$ is given by the equation

$$d_2 - d_1 = 0^{\text{in}}.0033(\log t_2 - \log t_1)\frac{Q}{Q_0} \tag{6}$$

As the results in detail will be published in the next volume of the Lick Observatory Publications, it is only necessary to state here that the tabular value of Q corresponding to the observed rate of increase in the measured diameters of *Polaris* is 5.67, giving the tabular magnitude −1.77; hence, according to equation (5),

$$m_n = -1.77 + 5 \log 5.5 = 1.93 \tag{7}$$

When it is considered that this result for the magnitude of *Polaris* (differing only 0.07 from the adopted magnitude) is practically the same as that given by the 6-inch objective used in obtaining the data for determining the law, it would seem to indicate that the results obtained with different instruments are less heterogeneous than might naturally be expected; for in this case, not only are the apertures very different, but for the 33-inch telescope the ratio of aperture to focal length is only about one-third as great as it is for the DALLMEYER lens.

Discrepancies in the results given by different observers are probably largely due to the fact that the constants peculiar to each instrument have not been sufficiently sharply determined.

If a series of exposures of varying length be made on the same plate, any two of these exposures will determine the rate of growth by means of equation (6). The shorter exposure should not be less than one second. The tabular value of $\frac{Q}{Q_0}$ can then be found without reference to the constant of the instrument (using the uncorrected values of d) from the equation

$$\frac{Q}{Q_0} = \frac{d_2 - d_1}{0.0033(\log t_2 - \log t_1)} \tag{8}$$

and the magnitude m_n by means of equations (2) and (7). These same quantities can be more readily taken from the table soon to be published, as stated above.

Although, in my first experiments the formula appeared to hold good, even for stars three or four magnitudes brighter than *Polaris*, I did not at the time determine how far down the scale the results could be considered reliable.

The appearance of the New Star in *Auriga*, which it was desirable to follow photographically as long as possible, made it necessary to extend the investigation on stellar magnitudes to stars which were only visible in large telescopes.

As the 6-inch DALLMEYER lens with which the original investigations were first carried on was no longer available, a WILLARD lens (belonging to our CROCKER telescope) of the same aperture and similar construction was used. From a large number of exposures on *Polaris*, I found that the tabular values required the correction +0.0010 for this telescope. In other words the equation for the WILLARD lens is

$$d = 0.0065 + 0.0033\left(\log\frac{Q}{Q_0} + \frac{Q}{Q_0}\log t\right) \tag{9}$$

A discussion of some preliminary exposures of long duration made it evident that there is considerable uncertainty as to the proper method for measuring the images; especially is this the case for very bright and very faint stars. The boundaries of these images on the negatives are not perfectly sharp, so that different observers will not necessarily obtain the same absolute values for any given image.

After various trials for securing some definite system of measurement, I finally devised a method for long exposure, by means of which the relative photographic magnitudes of either very bright or very faint stars can be determined with practically the same degree of accuracy as that obtained by short exposures on bright stars; a method, therefore, which gives the best possible results.

It is well known that by successive copying on slow plates contrasts of light and shade can, by proper exposures, be so much strengthened, that finally only uniformly opaque and transparent films remain, without apparent gradation from one into the other; that is, the boundary between the opaque and transparent surface is sharply defined.

Making use of this principle, I selected a negative of the region around *Nova Aurigae* which had an exposure of 150^m. A suitable positive was then made, on a slow plate, by direct contact. I then used this positive to make a second negative, also on a slow plate. Finally this last negative was in turn used to make a second positive, which I shall call the standard positive plate.

This plate contains considerably magnified images of all the stars on the original negative, with the additional peculiarity that all the stars, both bright and faint, are of the same *intrinsic* brilliancy; the *effective* brightness now simply depending upon the diameter of the sharply defined, uniformly illuminated stellar disks.

To determine the relation existing between the diameters of the disks on the standard positive plate and the corrected tabular values for the same magnitude, I first determined the photographic magnitude of β *Tauri*, *Polaris* and χ *Aurigae* from a large number of negative plates exposed on these stars, the exposure-times being 2, 4, 8, 16, 32, 64 and 128 seconds respectively.

Taking *Polaris* as a standard star of the second magnitude, the results are:

β *Tauri*,	1.08
Polaris,	2.00
χ *Aurigae*,	4.40

The diameters of the magnified images on the standard positive plate, exposure 150^m, are given below.

Star	Magnified Diam. Standard Plate	Tabular Diameter +0.0010	Ratio
β *Tauri*	0.1450	0.0285	5.1
χ *Aurigae*	0.0445	0.0093	4.9

The ratio 5.0 can, for practicable purposes, be applied to all images found upon the standard positive plate, as a change of as much as twenty per cent. in this ratio will only result in a change of about two-tenths of a magnitude for the faintest stars.

To the nearest tenth of a magnitude equation (9) shows that the theoretical diameter of the faintest stellar image accorded on the original negative is $0^{in}.0001$, corresponding to the theoretical magnitude 11.9.

On the standard positive plate the diameter of the smallest sharply defined image is about $0^{in}.0020$, giving for the above ratio the value $0^{in}.0004$ as the corrected tabular diameter, corresponding to the theoretical magnitude 11.5. The theoretical magnitude of any other star represented on this same plate can, for the same scale, be at once taken from the following table by simple interpolation, in which

$$d = 5(\text{tabular } d + 0.0010).$$

Theoretical Magnitude	Standard Positive Plate Measured *d*
12.0	$0^{in}.0000$
11.0	.0040
10.0	.0075
9.0	.0120
8.0	.0170
7.0	.0225
6.0	.0295
5.0	.0390
4.0	.0515
3.0	.0690
2.0	.0970
1.0	.1390
0.0	0.2000

Up to March 10 the exposures on *Nova* were respectively 2, 4, 8, 16, 32, 64 and 128 seconds, the comparison-stars on the same plate being χ *Aurigae*, and DM. +30°, Nos. 898 and 963. The mean photographic magnitudes of these stars in terms of *Polaris* I found to be 4.40, 5.22 and 4.98. Both of the DM. stars seem to fluctuate in brightness, using χ *Aurigae* as a standard.

After *Nova* was too faint for accurate measurements for such short exposures a single long exposure was usually made. As it would have been very laborious to determine the constant for each plate, and as the forms of the images would be slightly different for varying times of exposure, — thus introducing considerable uncertainty as to the proper method of making the measures, — I deemed it best to use one of these plates as a standard to which all the other plates should be referred. To remove all doubt as to the proper method of making measures consistent among themselves, the above described *copy* was made and employed as a standard of reference.

On each night's plate at least three different stars were selected in the neighborhood of *Nova*, which presented as nearly as possible the same density, form and size as the variable. Often it was very apparent that no star exactly resembled *Nova*; in such cases the brightness of the variable was found by interpolation, using stars both brighter and fainter than *Nova* for comparison. The photographic magnitudes of these particular comparison-stars were then determined by direct measurements of their images on the standard positive plate. To eliminate to some degree any unknown fluctuations in the light of the comparison-stars from day to day, each magnitude of *Nova* has been made to depend upon at least three different comparison-stars.

My photographic magnitudes of *Nova* found in this way begin with March 10, and continue to the end of the series. All the magnitudes determined previous to March 10 are deduced from short exposures varying from $(2)^0$ to $(2)^7$ seconds duration.

THEORETICAL PHOTOGRAPHIC MAGNITUDES OF *Nova Aurigae*.

Date 1892	Mt. Hamilt. M.T.	Mag.	Remarks
	h m		
Feb. 6	12 30	4.63	(a)
8	7 20	4.54	(a)
9	9 40	4.67	(a) Mean of two sets
10	10 7	4.77	(a) " " "
11	8 55	4.4	(a) Poor focus. Depends only on χ [illegible]
12	7 20	4.5	(a) " "
13	9 20	4.3	(a) " "
14	7 40	4.03	(a) Depends only on χ *Aurigae*
15	6 15	5.22	(a)
21	10 10	4.96	(a) Mean of two sets
22	9 30	5.12	(a) Mean of five sets
24	7 ±	4.84	(a) Also long exposure of one hour's durat[illegible]
25	8 55	4.90	(a) Mean of three sets
26	9 50	5.04	(a) Mean of three sets. Also long exposure [illegible]
27	8 20	4.75	(a) Mean of two sets. Also long exposure, [illegible]
28	8 50	4.98	(a)
Mar. 2	10 15	5.20	(a) Mean of two sets

Date 1892	Mt. Hamilt. M.T.	Mag.	Remarks
Mar. 3	9 10	5.09	(a) Mean [illegible]
4	8 25	5.63	
6	9 15	5.40	(b)
7	9 40	5.90	(b)
8	9 10	6.09	(b)
9	8 55	6.16	(b)
10	8 ±	7.10	(b) Exposure [illegible]
11	8 ±	7.70	(b) [illegible]
13	8 24	7.70	(b) [illegible]
15	11 9	8.45	(b) [illegible]
16	8 35	8.60	(b) [illegible]
20	8 56	9.25	(b) [illegible]
21	8 50	9.40	(b) [illegible]
22	9 17	9.55	(b) [illegible]*
24	9 2	9.80	[illegible]*
25	9 10	10.00	[illegible]*

(*a*) Mag. by short exposures. (*b*) Mag. by standard plate.

*These long exposures were made to determine the form of a new nebula discovered on the plate exposed Mar[illegible] 2[illegible]. (See *Publications A. S. P.*, Vol. IV, p. 85). Less than an hour's exposure would have been amply sufficient to obtain good images of the variable.

Towards the close of this series the bad weather set in, so that long exposures could not be made: the photographic work was therefore discontinued after March 25.

The visual determinations made by Professors HOLDEN, CAMPBELL and myself, cannot be expressed in magnitudes until the brightness of the comparison-stars have been photometrically determined.

The variations in the visual brightness of *Nova* during February were very marked; the photographic results, in a general way, agree with the visual in confirming the reality of these fluctuations. During February, therefore, discrepancies between results obtained at different stations may be due to actual variations in the light of *Nova*, unless the exposures were made at the same time.

The purely theoretical determinations of magnitude here given (based as they are on an empirical formula of a very general character), have no connection with the corresponding visual magnitudes other than assuming *Polaris* as a standard star of the magnitude 2.00, and using the light-ratio 2.5.

In conclusion, it may be of interest to state, that according to the formula a star of the 13th photographic magnitude cannot, practically, be photographed with a 6-inch telescope. The same formula places a star of the 17th photographic magnitude beyond the reach of our 33-inch photographic telescope.

Mt. Hamilton, 1892 *May* 18.

OBSERVATIONS OF COMET *a* 1892 (*SWIFT*),

MADE AT THE HAVERFORD COLLEGE OBSERVATORY WITH THE 10-INCH EQUATORIAL.

[Communicated by Prof. F. P. LEAVENWORTH.]

1892 Haverford M.T.		✱	No. Comp.	☄ — ✱		☄'s apparent		log *p* Δ		Obs.
				Δα	*Δδ*	*α*	*δ*	for *α*	for *δ*	
d	h m s			m s	′ ″	h m s	° ′ ″			
Apr. 6	16 25 57	1	7	−0 5.52	. . . .	21 10 55.19	. . . . . .	*n*9.632	. . .	D
23	16 18 46	2	5 , 3	−1 17.44	+0 31.4	22 9 50.77	+15 0 39.6	*n*9.784	0.642	L
26	15 51 26	3	6 , 1	+3 21.16	+0 5.2	22 19 20.05	+17 25 31.6	*n*9.619	0.643	G
	15 51 26	4	6	+0 48.50	. . . .	22 19 20.14	. . . . . .	*n*9.619	. . .	G
May 4	15 17 10	5	10 , 6	−0 27.24	−2 19.1	22 43 36.50	+23 16 57.9	*n*9.660	0.623	C
11	15 53 12	6	4 , 1	−6 53.40	+3 17.2	23 3 35.83	+27 43 4.7	*n*9.632	0.517	C
	15 53 12	7	4 , 1	−7 11.09	+5 1.1	23 3 36.04	+27 43 7.2	*n*9.632	0.517	C
17	14 32 29	8	10	+2 53.40	. . . .	23 19 31.46	. . . . . .	*n*9.708	. . .	C
	15 41 15	8	5	. . . .	−8 52.9	. . . . . .	+31 1 5.5	. . .	0.591	C
	14 32 29	9	10 , 5	−1 10.72	−7 53.8	23 19 31.62	+31 1 6.3	*n*9.708	0.591	C

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	21 11 1.26	—0.55	. . . .	. . . .	Seeliger, Vol. I, 27830
2	22 11 8.75	—0.51	+15 0 18.5	—13.1	Schjellerup 9123
3	22 15 59.13	—0.51	+17 25 39.8	—13.1	Seeliger, Vol. I, 30772
4	22 18 32.18	—0.51	. . . .	. . . .	Seeliger, Vol. I, 30866
5	22 41 3.25	—0.52	+23 19 29.0	—13.0	W. Bessel XXII, ½(986+987)
6	23 10 29.77	—0.51	+27 39 30.8	—13.3	Yarnall (F) 10533
7	23 10 17.67	—0.51	+27 38 19.3	—13.3	B.A.C. 8099
8	23 16 38.48	—0.42	+31 13 11.6	—12.4	⅓(W. Bessel 306,7) + ⅔(Leiden, Vol. V)
9	23 21 12.79	—0.45	+31 9 12.2	—12.1	⅓(W. Bessel 395,6) + ⅔(Leiden, Vol. V)

L = LEAVENWORTH. D = J. H. DENNIS. G = E. H. GIFFORD. C = WM. H. COLLINS.

FILAR-MICROMETER OBSERVATIONS OF COMET *a* 1892 (*SWIFT*),

MADE WITH THE 7-INCH EQUATORIAL OF BOSTON UNIVERSITY OBSERVATORY,

BY J. B. COIT.

1892 Washington M. T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
d h m s			s	′ ″	h m s	° ′ ″		
Mar. 16 16 45 4.9	1	3 , 3	+ 8.00	—3 1.5	19 46 22.12	—22 32 33.1	*n*9.515	0.862
Apr. 13 14 45 52.2	2	5 , 2	—15.58	+1 33.1	21 36 4.69	+ 5 57 9.5	*n*9.624	0.756
15 25 28.2	2	6 , 2	— 9.87	+3 10.5	21 36 10.40	+ 5 58 16.9	*n*9.595	0.748
18 14 28 57.1	3	5 , 2	—23.60	+7 49.1	21 53 8.46	+10 36 43.7	*n*9.637	0.745
May 4 14 0 45.0	4	6 , 2	—35.72	—4 47.8	22 43 26.81	+23 14 27.2	*n*9.672	0.703
15 8 19.7	4	13 , 4	—27.62	—3 0.8	22 43 34.91	+23 16 14.2	*n*9.634	0.639

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	19 46 14.88	—0.76	—22 29 24.1	— 7.5	Yarnall 8740
2	21 36 20.86	—0.59	+ 5 55 49.1	—12.7	Weisse's Bessel 826
3	21 53 32.62	—0.56	+10 29 7.5	—12.9	½(Weisse's Bessel 1212+Lamont 2878)
4	22 14 3.04	—0.51	+23 19 28.0	—13.0	Römker 10655

DOUBLE STARS.

BY J. E. GORE.

With reference to Professor HALL's interesting paper on Double Stars, in the *Astronomical Journal* for May 10, 1892, (Vol. XII, No. 1), I would like to point out that an orbit for 36 *Andromedae* = Σ73 was computed by Dr. DOBERCK in the year 1875. He found a period of 349.1 years, with periastron passage in 1798.80, and an eccentricity of 0.6537 (*Astr. Nach.*, No. 2052).

An orbit for Σ228 was computed by me in 1889, and the elements were published in the *Monthly Notices* of the Royal Astronomical Society for December, 1889 (Vol. L, No. 2). I found a period of 88.73 years, with periastron passage in 1906, and an eccentricity of 0.5311. My elements represent the measures from 1829 to 1889 fairly well, both in angle and distance, but Prof. HALL's recent measures tend to show that the period will be somewhat shorter than I found.

Ballysodare, Ireland, 1892 *June* 9.

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ON THE PROPER MOTION AND PARALLAX OF δ *EQUULEI.*

By F. P. LEAVENWORTH.

δ *Equulei* is a close binary star, with a period of about twelve years. It is of the fourth magnitude, and has a proper motion of three-tenths of a second of arc. Near it, but not sharing its proper motion, is a third star of the tenth magnitude. On these accounts it seemed an interesting pair to measure for difference of parallax.

In order to satisfy myself that the change appearing in the measures was due to proper motion of the principal star, I have made a new computation of this motion. All measures that could be procured were used. The earlier measures, with the exception of STRUVE'S, and all measures of a single night, were given less weight. These observations, reduced to 1875.0 and corrected for differential refraction, are given in the following table. The formulas that best represent them are

$$s \sin p = +15''.053 - 0''.0482\,(T - 1875.0)$$
$$s \cos p = +33''.664 + 0''.2995\,(T - 1875.0)$$

The proper motion of this star from meridian observations is given by OSCAR STUMPE in the *Astr. Nachr.*, No. 3000,

$$\Delta\alpha = +0^s.0012 \qquad \Delta\delta = -0''.286$$

and the proper motion from the above formulas is

$$\Delta\alpha = +0^s.0027 \qquad \Delta\delta = -0''.300$$

The companion, therefore, has little or no proper motion.

Observer	Date	p	s	O — C $s \sin p$	O — C $s \cos p$	Wt.
		°	″	″	″	
W. Herschel	1781.80	78.75	19.54	—0.33	—1.94	½
South	1825.26	42.08	25.82	—0.15	+0.10	½
Struve	1828.80	41.56	26.65	+0.40	+0.11	1
J. Herschel	1830.35	39.66	27.84	+0.57	+1.14	½
Smyth	1830.67	38.96	27.14	—0.14	+0.70	½
Struve	1832.10	39.85	27.49	+0.19	—0.20	1
"	1834.90	37.95	27.57	—0.03	+0.09	1
"	1835.64	37.94	27.61	+0.03	—0.08	1
"	1836.65	37.54	28.08	+0.21	+0.09	1
Smyth	1836.78	37.75	27.91	+0.20	—0.14	½
Struve	1837.77	36.83	28.27	+0.08	+0.27	1
Smyth	1838.59	36.94	28.21	+0.11	—0.21	½
O. Struve	1841.65	34.92	28.84	—0.15	—0.03	½
Kaiser	1842.61	34.13	28.52	—0.61	—0.37	½

Observer	Date	p	s	O — C $s \sin p$	O — C $s \cos p$	Wt.
Mädler	1843.63	35.02	29.30	+0.60	+0.22	
Kaiser	1844.17	34.02	29.22	+0.13	—0.22	
O. Struve	1847.82	32.29	30.50	0.00	+0.26	
"	1852.23	30.98	31.24	—0.07	—0.06	1
"	1854.30	29.67	31.63	—0.40	+0.04	1
"	1857.12	29.06	32.50	—0.11	+0.08	1
"	1859.12	28.35	32.88	—0.20	+0.02	1
Dembowski	1862.71	27.35	33.55	—0.26	—0.07	1
"	1863.64	26.95	33.91	—0.24	—0.02	1
"	1864.90	26.91	34.31	+0.03	—0.05	1
Knott	1865.72	27.54	34.18	+0.44	—0.46	½
O. Struve	1865.91	26.12	34.72	—0.20	+0.28	½
Dunér	1869.67	25.51	35.82	+0.12	+0.26	1
Seabroke	1876.81	24.21	37.68	+0.48	+0.17	½
Flammarion	1877.82	23.99	37.59	+0.36	—0.17	½
Burnham	1880.60	22.58	37.99	—0.23	—0.21	1
"	1881.46	22.28	38.60	—0.09	+0.13	1
Perrotin	1883.65	21.97	39.26	+0.08	+0.14	1
Leavenworth	1889.68	20.55	40.38	—0.18	—0.24	1
"	1890.88	20.74	41.03	+0.22	—0.04	1
"	1891.66	20.54	41.02	+0.17	—0.26	1

The observations for parallax are measures of distance alone. The principal star in all cases appeared single. The sum of the corrections for aberration and refraction, amounting in no instance to more than a few hundredths of a second, together with the assumed proper motion, have been applied. The corrected distances, with the date of observation, are given in the following table:

Date	Hour Angle	Facr.	Distance	[illegible]
1889.512	—2 39	69	10.445	10.874
9.515	—2 20	68	10.423	[illegible]
9.529	+1 33	72	10.26[illegible]	10.[illegible]67
9.540	+1 41	59	10.308	10.708
9.731	+2 3	60	10.531	10.881
9.756	+2 27	51	10.50[illegible]	10.849
9.761	+2 19	52	10.193	10.534
9.772	+0 33	45	10.263	10.5[illegible]7
9.800	+2 11	56	10.454	10.78[illegible]
1889.852	+1 58	59	10.[illegible]	[illegible]

Date	Hour Angle	Ther.	Distance	Distance 1891.0
	h m		″	″
1889.923	+2 11	46	40.546	40.845
89.975	+3 51	12	40.283	40.579
90.851	+1 26	62	41.043	41.095
0.873	+2 25	60	41.038	41.087
90.900	+4 31	38	41.001	41.060
91.516	—0 51	19	40.914	40.797
1.524	—2 12	62	40.846	40.728
1.530	—2 12	64	40.953	40.833
1.536	—1 31	70	41.099	40.977
1.560	—0 29	66	41.092	40.962
1.864	+2 35	50	40.938	40.720
1.883	+2 15	28	41.184	40.968
1891.889	+1 59	40	41.013	40.825

From these were formed the equations of condition, the distance for 1891.0 being assumed to be 40″.819.

Equation	Residual
	″
$x - 1.188y - 0.660\Pi - 0.035 = 0$	—0.119
$-1.185 \quad -0.655 \quad -0.011 = 0$	—0.095
$-1.171 \quad -0.626 \quad +0.152 = 0$	+0.069
$-1.160 \quad -0.601 \quad +0.111 = 0$	+0.030
$-1.269 \quad +0.143 \quad -0.065 = 0$	—0.121
$-1.241 \quad +0.218 \quad -0.030 = 0$	—0.082
$-1.239 \quad +0.271 \quad +0.285 = 0$	+0.234
$-1.228 \quad +0.315 \quad +0.222 = 0$	+0.172
$-1.200 \quad +0.419 \quad +0.036 = 0$	—0.010
$-1.148 \quad +0.580 \quad +0.158 = 0$	+0.119
$x - 1.077y + 0.694\Pi - 0.026 = 0$	—0.059

Haverford College Observatory, 1892 *June* 10.

Equation	Residual
	″
$x - 1.025y + 0.688\Pi + 0.240 = 0$	+0.211
$-0.149 \quad +0.575 \quad -0.276 = 0$	—0.245
$-0.127 \quad +0.625 \quad -0.268 = 0$	—0.235
$-0.100 \quad +0.671 \quad -0.241 = 0$	—0.203
$+0.516 \quad -0.720 \quad +0.022 = 0$	+0.077
$+0.521 \quad -0.721 \quad +0.091 = 0$	+0.147
$+0.530 \quad -0.720 \quad -0.014 = 0$	+0.042
$+0.536 \quad -0.720 \quad -0.158 = 0$	—0.102
$+0.560 \quad -0.705 \quad -0.143 = 0$	—0.084
$+0.861 \quad +0.601 \quad +0.099 = 0$	+0.201
$+0.883 \quad +0.643 \quad -0.119 = 0$	—0.045
$x + 0.889y + 0.652\Pi - 0.006 = 0$	+0.099

From these were derived the normal equations,

$$\begin{aligned} +23.000x - 10.408y + 1.000\Pi - 0''.006 &= 0 \\ -10.408x + 23.672y - 0.553\Pi - 1.330 &= 0 \\ +\ 1.000x - \ 0.553y + 8.285\Pi - 0.132 &= 0 \end{aligned}$$

the solution of which gives

$$\begin{aligned} x &= +0''.031 \quad \pm 0''.024 \\ y &= +0.070 \quad \pm 0.023 \\ \Pi &= +0.017 \quad \pm 0.035 \\ r &= \qquad\qquad \pm 0.102 \end{aligned}$$

weight π 8.241

$[nn3]$ 0″.453

$[vv]$ 0.452

Gore's hypothetical parallax for this star is 0″.08.

OBSERVATIONS OF VARIABLE STARS OF THE *ALGOL*-TYPE, 1891-1892,

By PAUL S. YENDELL.

The within detailed observations are in continuation of the line of work on the stars of this type, whose results have been published in the three preceding volumes of this Journal.

Only six out of the ten known stars of the class are included in the present paper, no minima having been observed of *U Cephei*, *δ Librae*, *U Coronae*, or *S Cancri*. The already published minima of *Y Cygni*, and *λ Tauri*, for 1891, are here repeated, for the purpose of comparison of the results of the different processes of reduction; a tolerable provisional mean light-curve having been formed from the seventy-five observations of *λ Tauri* obtained by me during the past two seasons. For *S Antliae* the curve constructed in 1891 has been used, as representing the star's variation fairly well; for *Algol*, that of Schönfeld, and for *U Ophiuchi*, Chandler's.

In addition to the three different methods of reduction, I have thought it of interest to give the least observed light at each minimum, as in several cases there is a suspicion that the extent of variation may not be uniform.

The time used is the local mean time.

1090. *Algol.*

One minimum only has been observed during the year.

1892 Feb. 16; fifteen observations, from 7h 20m to 10h 30m.

Time of minimum by single curve 8h 56m.5, wt. 4.

" " mean curve, 9h 14m.4.

" " equal brightness,

	Before	After	Mean
M	h m	h m	h m
3.4	8 26	10 1	9 13.5

Least observed light, 3M.6

1411. *λ Tauri.*

Four minima have been observed.

1891 Oct. 17; ten observations, from 9h 11m to 13h 11m.

Time of minimum by single curve 10h 58m, w. 4. By some error of transcription or printing, this was erroneously published as 10h 28m.

Time of minimum by mean curve 11h 5m.5.

" " equal light.

	Before	After	Mean
M	h m	h m	h m
4.0	9 28	12 56	11 7
4.1	10 16	11 37	10 56.5
Mean of middle light			11 1.75

Least observed light, $4^M.13$. Moon full.

1411. *λ Tauri.*

1891 Oct. 21; seven observations, from $8^h 38^m$ to $11^h 28^m$.
Time of minimum by single curve, $10^h 22^m$, w. 4.
" " mean curve, $10^h 9^m.7$.
" " equal light

	Before	After	Mean
M	h m	h m	h m
3.8	9 20	11 4	10 12.0
3.9	9 37	10 56	10 16.5
4.0	10 8	10 48	10 28.0
Mean of middle light			10 18.8

Least observed light, $4^M.02$. Moon bright.

1891 Oct. 25; twelve observations, from $8^h 5^m$ to $11^h 45^m$.
Time of minimum by single curve, $10^h 10^m$, w. 4.
" " mean curve, $9^h 59^m.6$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
4.0	9 7	10 52	9 59.5
4.1	9 35	10 41	10 8.0
4.2	9 57	10 26	10 11.5
Mean of middle light			10 6.3

Least observed light, $4^M.23$.

1891 Oct. 29; seven observations, from $8^h 2^m$ to $10^h 8^m$.
Time of minimum by single curve, $8^h 59^m$, w. 3.
" " mean curve, $8^h 41^m$
" " equal light,

	Before	After	Mean
M	h m	h m	h m
4.0	8 18	9 24	8 51

Least observed light, $4^M.08$.

2610. *R Canis Majoris.*

Three minima were observed.
1892 Feb. 16; eleven observations, from $7^h 29^m$ to $10^h 54^m$.
Time of minimum by single curve, $9^h 32^m$, w. 4.
" " equal light.

	Before	After	Mean
M	h m	h m	h m
6.5	8 57	10 19	9 38.0
6.6	9 4	9 53	9 28.5
6.7	9 11	9 49	9 30.0
6.8	9 16	9 44	9 30.0
6.9	9 21	9 40	9 30.5
Mean of middle light			9 31.4

Least observed light, $7^M.0$.

1892 March 4; twelve observations, from $7^h 15^m$ to $11^h 10^m$.
Time of minimum by single curve, $10^h 49^m$, w. 3.
" " equal light.

	Before	After	Mean
M	h m	h m	h m
7.0	10 21	11 8	10 44.5
7.1	10 25	11 4	10 44.5
Mean of middle light			10 44.5

Least observed light, $7^M.22$.

1892 April 6; nine observations, from $7^h 45^m$ to $9^h 40^m$.
Time of minimum by single curve, $8^h 52^m$, w. 4.
" " equal light.

	Before	After	Mean
M	h m	h m	h m
6.4	8 37	9 12	8 54.5
6.5	8 49	8 58	8 53.5
Mean of middle light, $6^M.67$.			8 54.0

Least observed light $6^M.67$.

3407. *S Antliae.*

Eight minima.
1891 Dec. 28; eight observations, from $14^h 25^m$ to $15^h 30^m$.
Time of minimum by mean light curve, $16^h 27^m$.

1892 Jan. 25; twelve observations, from $12^h 5^m$ to $13^h 55^m$.
Time of minimum by single curve, $13^h 39^m$, w. 1.
" " mean curve, $13^h 35^m$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
7.1	13 17	13 49	13 33

Least observed light, $7^M.17$.

1892 March 19; twelve observations, from $7^h 30^m$ to $9^h 58^m$.
Time of minimum by single curve, $9^h 13^m$, w. 4.
" " mean curve, $9^h 5^m$.
" " equal light.

	Before	After	Mean
M	h m	h m	h m
6.9	8 32	9 58	9 15
7.0	8 49	9 35	9 12
7.1	9 2	9 20	9 11
Mean of middle light			9 12.7

Least observed light, $7^M.12$.

1892 March 21; eleven observations, from $7^h 39^m$ to [illegible] 16^m.
Time of minimum by single curve, $8^h 52^m$, w. 4
" " mean curve, $8^h 47^m$.
" " equal light.

	Before	After	Mean
M	h m	h m	h m
6.9	8 19	9 14	8 46.5
7.0	8 38	9 7	8 52.5
Mean of middle light			8 49.5

Least observed light, $7^M.08$.

1892 Mar. 30; fourteen observations, from 8^h 40^m to 10^h 10^m.
Time of minimum by single curve, 9^h 37^m, w. 3.
" " mean curve, 9^h $44^m.3$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
7.1	9 19	9 55	9 37

Least observed light, $7^M.2$.

1892 March 31; eleven observations, from 8^h 5^m to 9^h 55^m.
Time of minimum by single curve, 9^h 30^m, w. 5.
" " mean curve, 9^h $24^m.8$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
7.1	9 8	9 40	9 24

Least observed light, $7^M.17$.

1892 April 1: nine observations, from 7^h 40^m to 9^h 30^m.
Time of minimum by single curve, 8^h 37^m, w. 4.
" " mean curve, 8^h $38^m.8$.
" " equal light,

	Before	After	Mean
	h m	h m	h m
6.9	8 4	9 25	8 44.5
7.0	8 19	9 9	8 44.0
7.1	8 34	8 40	8 37.0
Mean of middle light			8 42.9

Least observed light, $7^M.12$.

1892 April 23; six observations, from 9^h 0^m to 9^h 43^m.
Time of minimum by single curve, 9^h $13^m.5$, w. 3.
" " mean curve, 9^h $13^m.4$.
Least observed light, $7^M.2$.

1892 April 24; eight observations, from 8^h 0^m to 9^h 35^m.
Time of minimum by single curve, 8^h 39^m, w. 4.
" " mean curve, 8^h 39^m.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
7.1	8 18	8 58	8 38

Least observed light, $7^M.19$.

Two minima were partially observed, as follows:
1892 April 13; five observations, from 7^h 50^m to 9^h 0^m.
Time of minimum by mean curve, 7^h 41^m.

1892 April 25; two observations, 8^h 15^m, and 8^h 30^m.
Time of minimum by mean curve, 8^h $18^m.5$.

6189. *U Ophiuchi.*

Four minima.
1891 June 8; ten observations, from 9^h 0^m to 11^h 0^m.
Time of minimum by single curve, 10^h 8^m, w. 4.
" " mean curve, 10^h $9^m.5$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
6.5	9 11	10 55	10 3
6.6	9 45	10 25	10 5
Mean of middle light			10 4

Least observed light, $6^M.66$.

1891 Aug. 25; sixteen observations, from 8^h 2^m to 11^h 8^m.
Time of minimum by single curve, 10^h 34^m, w. 4.
" " mean curve, 10^h $19^m.7$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
6.7	10 17	10 38	10 27.5

Least observed light, $6^M.8$.

1891 Sept. 10; ten observations, from 7^h 28^m to 9^h 43^m
Time of minimum by single curve, 8^h 41^m, w. 4.
" " mean curve, 8^h $37^m.5$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
6.7	8 18	9 10	8 44

1891 Oct. 1; four observations.
Time of minimum by single curve, 8^h 0^m, w. 4.
" " mean curve, 8^h 13^m.
Least observed light, $6^M.6$.

1891 Aug. 20; four observations, from 7^h 50^m to 9^h 9^m; no minimum observed.

Time of minimum by mean curve, 9^h $12^m.6$.

7488. *Y Cygni.*

Thirteen minima.

1891 Aug. 20; eight observations, from 13^h 45^m to 16^h 5^m; actual minimum not observed.

Time of minimum by mean curve, 14^h $44^m.4$.

1891 Sept. 16; sixteen observations, from 8^h 55^m to 15^h 22^m.
Time of minimum by single curve, 13^h 15^m, w 4.
" " mean curve, 13^h $16^m.8$.
" " equal light.

	Before	After	Mean
M	h m	h m	h m
8.2	11 58	14 22	13 10
8.3	12 26	13 53	13 9.5
Mean of middle light			13 9.75

Least observed light, $8^M.4$.

1891 Sept. 19; fourteen observations, from 11^h 0^m to 15^h 15^m.

Time of minimum by single curve, 12^h 56^m, w. 5.
" " mean curve, 12^h 56^m.
" " equal light

	Before	After	Mean
M	h m	h m	h m
8.2	11 14	14 5	12 44.5
8.3	11 46	13 44	12 45.0
8.4	12 24	13 25	12 54.5
Mean of middle light			12 48

Least observed light, $8^M.43$.

1891 Sept. 25; seven observations, from $9^h 50^m$ to $13^h 50^m$.
Time of minimum by single curve, $12^h 16^m$, w. 4.
" " mean curve, $12^h 16^m$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.2	11 22	13 30	12 56
8.3	12 12	13 6	12 39
Mean of middle light			12 47.5

Least observed light, $8^M.34$.

1891 Oct. 16; seven observations, from $9^h 20^m$ to $11^h 18^m$.
Time of minimum by single curve, $10^h 33^m$, w. 4.
" " mean curve, $10^h 54^m$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.2	9 30	11 40	10 35
8.3	9 44	11 33	10 33.5
Mean of middle light			10 34.25

Least observed light, $8^M.4$.

1891 Oct. 25; seventeen observations, from $7^h 30^m$ to $11^h 35^m$.
Time of minimum by single curve, $10^h 28^m$, w. 3.
" " mean curve, $10^h 18^m.2$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.2	8 46	11 26	10 6
8.3	9 19	11 7	10 13
Mean of middle light			10 9.5

Least observed light, $8^M.4$.

1891 Oct. 28; twelve observations, from $7^h 50^m$ to $11^h 25^m$.
Time of minimum by single curve, $10^h 32^m$, w. 5.
" " mean curve, $10^h 26^m.8$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.3	9 48	11 25	10 37.5

Least observed light, $8^M.42$.

1891 Nov. 3; ten observations, from $8^h 12^m$ to $11^h 15^m$.
Time of minimum by single curve, $10^h 16^m$, w. 5.
" " mean curve, $10^h 25^m.8$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.3	9 32	10 53	10 12.5
8.4	10 0	10 34	10 17
Mean of middle light			10 14.75

Least observed light, $8^M.44$.

Dorchester, Mass., 1892 *June* 23.

1891 Nov. 6; eleven observations, from $7^h 52^m$ to $11^h 55^m$.
Time of minimum by single curve, $10^h 20^m$, w. 5.
" " mean curve, $10^h 6^m.3$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.2	9 0	11 4	10 2
8.3	9 16	10 48	10 17
Mean of middle light			10 9.5

Least observed light, $8^M.44$.

1891 Nov. 18; thirteen observations, from $7^h 25^m$ to $11^h 17^m$.
Time of minimum by single curve, $10^h 32^m.5$, w. 2.
" " mean curve, $10^h 4^m.5$.

Least observed light, $8^M.27$.

1891 Nov. 27; twelve observations, from $7^h 30^m$ to $10^h 50^m$.
Time of minimum by single curve, $9^h 21^m.0$, w. 4.
" " mean curve, $9^h 41^m.6$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.2	7 50	10 35	9 12.5
8.3	8 44	10 7	9 25.5
Mean of middle light			9 19.0

Least observed light, $8^M.44$.

1891 Nov. 30; eight observations, from $7^h 50^m$ to $10^h 0^m$.
Time of minimum by single curve, $9^h 11^m$, w. 1.
" " mean curve, $9^h 8^m.9$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.2	7 55	9 54	8 54.5
8.3	8 29	9 39	9 4.0
8.4	9 6	9 14	9 10.0
Mean of middle light			9 2.8

Least observed light, $8^M.42$.

1891 Dec. 3; eleven observations, from $7^h 13^m$ to $10^h 20^m$.
Time of minimum by single curve, $9^h 10^m$, w. 1.
" " mean curve, $9^h 18^m.7$.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.2	8 0	9 37	8 48.5
8.3	8 47	9 28	9 17.5
8.4	9 17	9 21	9 19.0
Mean of middle light			9 8.3

Least observed light, $8^M.44$.

OBSERVATIONS OF VARIABLE STARS IN 1891,

BY EDWIN F. SAWYER

1072 *ρ Persei.*

This star was under observation from 1890 September 18 to 1891 April 9, the observations numbering 22. When first seen, September 18, *ρ* was nearly at its normal brightness or 3 steps > *κ Persei*. A slight depression occurred about October 1 representing a bright minimum. The star brightened after October 12, the light remaining nearly constant until February 27, when the light again faded and a second bright minimum was passed about March 23. On April 9, the date of the last observation, *ρ* had brightened slightly.

2100 *U Orionis.*

Twenty observations of this star were obtained, extending from 1890 December 18 to 1891 March 30. When first seen on December 18, *U* was ½ step > DM. 20°1168 and 5 steps < DM. 20 1171, or $8^{M}.6$. The increase of light was rapid and a maximum was passed about 1891 January 27.

(Observations interrupted from January 13 to 30). Observed maximum brightness was 4 steps > DM. 19 1106 and two steps < DM. 20°1156, or $6^{M}.9$; this representing a rather faint maximum. The light remained apparently constant from about January 12 to February 10, or 29 days. The decrease was slow and very uniform, and when last seen, on March 30, *U* was = DM. 20°1168, or about $8^{M}.6$.

4940 *W Hydrae.*

Although my discovery of the variability of this star was announced in 1889, no good determination of a maximum phase has yet been secured, owing to the fact that the period is very nearly one year, while the present series of maxima occur in the spring, when the star can only be observed in the early morning hours. The star was first detected this year on the morning of March 5 and estimated, from a comparison with the neighboring star, 18788 of GOULD'S General Catalogue, to be about $7^{M}.2$. It had increased in brightness 2 or 3 steps on March 10; and on March 30 it was estimated at about $6^{M}.8$. On April 9 the star had faded to $7^{M}.0$, and on May 3, the date of the last observation it had reached $7^{M}.5$.

A maximum is indicated about March 21? The few observations, 7 in number, secured in 1890, and extending from March 17 to May 11, give a maximum for March 25?

5667 *R Coronae.*

The observations on this star number 8, and extend from April 9 to June 3.

When first seen on April 9, *R* was at about its normal brightness or midway between the stars DM. 32°2621 and DM. 30°2682, or $6^{M}.3$. On April 27, *R* had faded to $6^{M}.6$, and continued to grow fainter until June 3, the date it was last observed, when it appeared very faint in the field-glass and was estimated to be $8^{M}.7$. It has not been seen since then, although occasionally looked for.

5912 *g Herculis.*

A fair series of observations, 30 in number, was obtained on this star, extending from April 9 to November 2. These observations when charted exhibit two maxima and two minima. The first maximum was a faint one and was passed on July 7. The second, a bright one, was reached on September 25.

The interval between the maxima was 80 days. The first minimum, indicated by a slight inflection only, was reached on June 10. The second, a faint one, was passed on August 11. The interval between the minima was 65 days.

6189 *U Ophiuchi.*

The following minima of this star have been determined since the publication, in No. 177 of this Journal, of my definitive discussion of all my observations to 1888. The times have all been calculated by means of the mean light-curve, by ARGELANDER'S method: and the comparison in the O—C column is with Dr. CHANDLER'S definitive elements.

Epoch	Observed Minimum Boston M.T.					Light Equat.	Wt.	O—C
			d	h	m	m		m
2991	1888	June	1	9	55.2	+7.6	4	—10.1
3006			11	11	27.7	+7.6	3	— 9.8
3025			27	9	53.0	+7.2	1	—10.6
3100		Aug.	29	7	56.6	+1.4	1	+11.6
3131	1888	Sept.	24	7	47.4	—2.0	4	+ 0.9
3465	1889	July	1	10	33.4	+7.1	4	+14.1
3565		Sept.	23	7	12.5	—1.6	2	— 2.6
4420	1891	Sept.	10	8	48.4	—0.2	5	+19.7

6733 *R Scuti.*

This star was observed from June 3 to November 27, 44 observations. The charted observations exhibit only one maximum and two minima. When first seen, on June 3, *R* was quite bright, having evidently but recently passed a maximum. *R* faded quite slowly until after July 16, when a more rapid decline occurred, and a faint minimum was passed on August 23; light = 5.0. The rise was very rapid and uniform, and a very bright maximum was reached October 1; light = 24.3; this being the brightest observed maximum since April 1883. It remained at maximum but a few days, rapidly declining and passing a second and bright minimum about November 9. When last observed, November 27, *R* was evidently brightening again.

7120 *χ Cygni.*

This star was observed on 20 nights from July 16 to October 5. When first seen on July 16, *χ* was 4 steps < DM.

33°3602, or about $7^{\mathrm{M}}.3$. The increase was very rapid, a maximum being passed August 14. Maximum brightness 4 steps < DM. 33°3587, and 3 steps > DM. 32°3531 or $5^{\mathrm{M}}.8$. The decrease was slow and uniform, and when last observed on October 5, χ was 5 + steps < DM. 33°3602 or about $7^{\mathrm{M}}.5$.

Brighton, Mass., 1892 *May*.

LIGHT–VARIATIONS OF *S PERSEI* AND *T ARIETIS*.

BY J. G. HAGEN, S. J.

In a former article with a similar title (*A.J.* No. 231, p. 115) a series of observations of these two stars between the years 1883 and 1888 was discussed by the writer. The results showed great irregularities in both periods, and owing to this circumstance a watch was kept on these stars for the last two years, although they lie outside the present plan of work in our observatory.

During the five years preceding 1888, the period of *S Persei* proved to be the longest of all yet known, and that of *T Arietis* showed a decided decrease.

From the present discussion it will appear that *S Persei* is maintaining its long period, although the light-curve has been very irregular, and that the period of *T Arietis* has kept decreasing at a uniform rate.

I. *S Persei.*

In the article referred to it was stated (p. 116), that the light of this star had only two maxima and three minima between the autumns of 1883 and 1888, and that this fact, though in discord with the elements of previous observers, was placed beyond doubt, as the star had been "followed almost throughout the whole year and the time of its invisibility was frequently recorded." This statement was confirmed by two other observers, — Šafařík and Hartwig.

The former found the period between the years 1880 and 1889 to range from 814 to 952 days (*A.N.* Bd. 126, p. 168), the latter found the intervals between succeeding maxima from 1879 until 1888 to be respectively 356, 667, 863 and 829 days (*V.J.S.*, 1891, p. 236).

A careful discussion of my own observations, extending over five years, gave the two well-determined maxima:

1885 March 11, and 1887 July 11,

with the interval of 852 days.

No observations of this star seem to have been published since, except a very interesting statement by Prof. Šafařík in this Journal (No. 261, p. 167), that the star reached nearly its full light unexpectedly early, and kept shining with almost constant brilliancy from July 1891 until March 1892.

My own observations were resumed in the autumn of 1890, when the star was near disappearance, and after its reappearance, they extend from September 1891 until the end of April of this year, when the light was again declining.

A preliminary reduction of the 22 observations showed some resemblance of the light-variations to those in 1884, and a comparison between the plotted curves gave with some degree of probability a *maximum about the beginning of March, 1892*, with the magnitude 7.9 of the DM. scale.

The interval from the last observed maximum, 1887 July 11, until 1891 March 2, and the day marked on the curve as the time of maximum, is

1696 = 2 × 848 days.

There was one intermediate maximum, which was put by Prof. Šafařík 1889 December 1.

The close agreement of the interval 2 × 848 with the one given in the former article, viz. 852, may be partly accidental; though it must be stated, that when determining the time of the last maximum no previous knowledge was had as to when it was to be expected.

It follows then, that although the light-curve of the last maximum was very irregular, the period does not seem to have changed much for the last eight years.

II. *T Arietis.*

The gradual decrease of period which was stated in the article already mentioned (p. 117), was not only confirmed by later observations, but proved to be uniform for the space of the last twenty years.

Observations of this star were resumed in October, 1890, and continued until the middle of March, 1892, with an interruption during the summer months, when the star was near the sun.

A preliminary reduction of all the 38 observations gave a light-curve with two maxima, one of which could be well determined.

This latter falls on 1892 January 16, whilst the other cannot be far from 1891 March 5.

The *inflection*, mentioned on page 118 of the former article, has again appeared before both maxima.

Table I will exhibit all the *maxima* that have come to notice (see this Journal, No. 231, p. 117, where the first column of Schönfeld's observations should be headed: *Minima*).

Table I.

E	Maxima	Jul. Day	Obs'r	Intervals
— 11	1873 Mar. 11	2 405 229	Sch.	
				323
— 10	1874 Jan. 28	2 405 552	Sch.	
				322
— 9	1874 Dec. 16	2 405 874	Sch.	
				315.5 × 15
+ 6	1887 Dec. 1	2 410 607	H.	
				300.8 × 5
+ 11	1892 Jan. 16	2 412 111	H.	

The principal epoch is that of the maximum in the autumn of 1882, or the twelfth since 1873.

The third column gives the Julian Day of the observed maxima.

From the last column it becomes at once evident, that the period is decreasing at the rate of about one day for every epoch. The final result will show, that this change may so far be supposed uniform.

If we assume the mean period to be 313 days approximately, and the maximum of 1882 to have occurred about October 31 (or the principal epoch to have fallen near the Julian Day 2 408 750), we have five equations of condition of the form:

$$\text{Maximum} = (8750 + x) + (313 + z)\,E - \tfrac{1}{2}\,(1 + y)\,E^2.$$

A solution by least squares gave the results:

$$x = -0^{d}.39$$
$$y = +0^{d}.311 \pm 0^{d}.012$$
$$z = +0^{d}.17 \pm 0^{d}.15$$

and consequently the elements:

$$\text{Maximum} = 1882,\ \text{October } 31 + 313.17\,E - 0.655\,E^2.$$

Georgetown College, 1892 *May* 29.

The small residuals of Table II prove the correctness of these elements for the interval from 1872 to 1892.

TABLE II.

E	Obs.	Comp.	O — C
			d
—11	2 405 229	5 226	+3
—10	2 405 552	5 553	—1
— 9	2 405 871	5 878	—4
+ 6	2 410 607	10 605	+2
+11	2 412 111	12 116	—2

From these elements, the next following maximum is to be expected 1892 Nov. 11. The maximum of 1893 will fall on Sept. 4, and cannot be obtained from evening observations, while that of 1894 June 26, will be entirely invisible.

In conclusion, attention may be called to the comparison-star g, which appears generally brighter than e [see this Journal, No. 231, p. 117, Table III], but at times decidedly fainter.

The presumption is, however, that the change depends on the season of the year, and consequently on the position of the observer. Since g is likely to be taken as comparison-star by all observers, a disregard of this circumstance will be apt to introduce sensible errors in the reductions.

FILAR-MICROMETER OBSERVATIONS OF COMET *a* 1892 (*SWIFT*),

MADE WITH THE 12-INCH EQUATORIAL OF VASSAR COLLEGE OBSERVATORY,

BY MARY W. WHITNEY.

1892 Poughkeepsie M.T.	✱	No. Comp.	☄ — ✱ $\Delta\alpha$	☄ — ✱ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
d h m s			m s	′ ″	h m s	° ′ ″		
April 26 15 51 35	1	4	+0 48.73	—3 37.3	22 19 20.17	17 25 29.6	n9.701	0.664
29 15 51 37	2	7	+1 16.70	+3 21.7	22 31 53.15	19 46 15.1	n9.613	0.649
May 1 15 41 4	3	7	—0 21.79	—2 19.3	22 13 38.17	23 16 54.1	n9.546	0.618

Mean Places for 1892.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 18 32.29	—0.55	17 29 20.1	—13.2	W. Bessel XXII, 367
2	22 30 37 00	—0.55	19 43 6.5	—13.1	W. Bessel XXII, 638
3	22 41 3.47	—0.51	23 19 26.4	—13.0	W. Bessel XXII, 986,7

NAME OF ASTEROID.

Dr. MAX WOLF writes from Heidelberg, that he has given to the asteroid 323, photographed by him, 1891 Nov. 28, the name *Brucia*. This, the first planet discovered by photography, is named in honor of Miss CATHERINE W. BRUCE, who has contributed so generously for the advancement of astronomy.

CONTENTS.

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REMARKS ON MR. CHANDLER'S LAW OF VARIATION OF TERRESTRIAL LATITUDES,

BY SIMON NEWCOMB.

The fact of a periodic variation of terrestrial latitudes, and the general law of that variation, have been established beyond reasonable doubt by the observations collected by Mr. Chandler. But two of his minor conclusions, as enumerated in No. 3 of this volume, do not seem to me well founded. They are: —

1. That the period of the inequality is a variable quantity.

2. That the amplitude of the inequality has remained constant for the last half century.

I must first point out a difficulty which arises in the determination of the amplitude in a case like the present one, in which the epoch is unknown, and the amplitude of the same order of magnitude as the systematic errors of the observations. In such a case the effect of the errors of observation is to make the apparent amplitude systematically too great.

In the problem of determining the parallax and aberration of a star, the epochs of maximum and minimum values of both quantities are known in advance, as a function of the sun's longitude. Consequently, the effect of errors of observation may as well be to diminish as to increase the true value of the constant, and we shall probably approximate to the truth in taking the mean of a great number of results. Let us see why it is different in the present case. We take the equations of condition in the form (9) given by Mr. Chandler on p. 18,

$$x + by + cz = n$$

After determining x and y from a system of such equations the amplitude r is found by the equation

$$r = \sqrt{y^2 + z^2}$$

To fix the ideas, suppose the true values of y and z to be zero, so that there is no actual variation of latitude. It is infinitely improbable that a discussion of any one series of observations will give the value 0 for both x and y; if ε and ε' be the errors of the results, we shall find from each series of observations such a result as

$$y = \pm\varepsilon \qquad z = \pm\varepsilon'$$

Thus we shall get

$$r = \sqrt{\varepsilon^2 + \varepsilon'^2}$$

a positive amplitude. Hence we should have from the discussion of any number of different series of observations an equal number of values of r,

$$r, r_1, r_2 \ldots \ldots r_n$$

all necessarily positive. The mean by weights of these would not be an approximation to the true value of r, which is zero by hypotheses, but only the mean error of the observations. How can we know then that the forty-five values of r tabulated by Mr. Chandler on p. 18 are anything else than so many errors in the determination of a quantity whose true value is zero? There are two tests which, to be conclusive, must be combined.

1. The mean value of r must be much greater than the probable mean errors of the observations. That is, we must have

$$\text{mean } r > \text{prob. } \sqrt{\varepsilon^2 + \varepsilon'^2}$$

We must then have some idea of the probable value of this last quantity. This idea may be formed in two ways, *a priori*, or by the discordances of the results among themselves. We begin with the latter, and with the [illegible] results which fall within Mr. Chandler's first period, 1840–60. The three best results are those of [illegible], 0".088 and 0".051, respectively. The other five results range between 0".211 and 0".568. These discordances show that, in a general way, the mean values of ε and ε' must be greater than 0".10 in the case of these eight results. Hence we may say

$$\text{prob. } \sqrt{\varepsilon^2 + \varepsilon'^2} > 0''.15$$

The mean value of r which Mr. Chandler finds for [illegible]

period is 0″.182.* The difference is too small to afford any basis for a conclusion, and shows that the variation was evanescent during the period in question.

But I must also remark that, *a priori*, the estimate $\varepsilon = +0''.10$ is too small. The systematic errors varying from month to month, and from season to season, with which every one who has discussed meridian observations is familiar, would lead to values of ε or ε' greater than this. I conclude, therefore, that so far as this first test goes, Mr. CHANDLER's numbers prove nothing; we can only say that they form such a series of results as we should expect if the variation were *nil*, the best observations giving small results, the others large ones.

The second test is, that the epochs of maximum or of minimum latitude form a series of numbers nearly in arithmetical progression. The results since 1860, at least such of them as are entitled to any weight, satisfy this test so well that there can be no doubt of the reality of the revolution of the axis of rotation, as indicated by theory. But, the question now arises how far we are entitled to assume that the period must be invariable. I reply that, perturbations aside, any variation of the period is in such direct conflict with the laws of dynamics that we are entitled to pronounce it impossible. But we know that there are perturbations, and I do not see how one can doubt that they have so acted as to increase the amplitude of the variation since 1840. The observations of STRUVE and PETERS show that the semi-amplitude was probably markedly *less* than 0″.06 during the years 1840–44, probably not greater than 0″.04 or 0″.05. And, as I have shown, no contemporary observations can invalidate this conclusion. But the semi-amplitude now appears to exceed 0″.20. Now, the disturbing causes which produced this increase would, at the same time, so change the longitude of the pole of rotation that the continuity of the period would probably be entirely broken. In view of the minuteness of the coefficient, after 1840, as shown by the Pulkowa observations, and the want of observations of the necessary precision during the next twenty years, it seems to me difficult to draw any conclusion as to the continuity of the period between 1840 and 1860.

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*This value is taken from the wrong column on p. 2. It should be 0″.217. — G.

ELEMENTS AND EPHEMERIS OF COMET *a* 1892 (*SWIFT*),*

BY MILTON UPDEGRAFF.

From observations made here on March 12, 22 and April 1, I have deduced the following elements and ephemeris of SWIFT's Comet. The corrections have been applied for parallax, aberration and the sun's latitude:

ELEMENTS.

$$T = \text{April } 6.611732 \quad \text{Greenw. M. T.}$$

$$\omega = 24^\circ\ 30'\ 41''.8$$

$$\Omega = 240\ \ 55\ \ 12.9$$

$$i = 38\ \ 42\ \ 41.6$$

$$\log q = 0.0115760$$

For the middle place, O—C = —3″.5 in longitude and +1″.2 in latitude.

HELIOCENTRIC COORDINATES.

$$x = [9.9229417]\, r \sin(319^\circ\ 2'\ 1''.6 + v)$$

$$y = [9.9997811]\, r \sin(257\ \ 50\ \ 46.5 + v)$$

$$z = [9.7383725]\, r \sin(345\ \ 3\ \ 51.7 + v)$$

EPHEMERIS FOR 12ʰ GREENWICH M.T.

1892	α h m s	δ ° ′ ″	log r	log Δ	Br.
June 30	0 44 55.20	+46 29 43.6	0.2318	0.2304	0.20
July 1	0 46 8.32	46 43 32.3			
2	0 47 19.20	46 57 6.3			
3	0 48 27.85	47 10 25.6	0.2407	0.2339	0.19
4	0 49 34.21	47 23 30.4			
5	0 50 38.27	47 36 21.1			
6	0 51 40.04	47 48 57.7	0.2495	0.2371	0.18
7	0 52 39.48	48 1 20.4			
8	0 53 36.56	48 13 29.5			
9	0 54 31.29	48 25 24.8	0.2581	0.2401	0.17
10	0 55 23.63	48 37 6.5			
July 11	0 56 13.55	+48 48 34.6			
July 12	0 57 1.05	+48 59 49.3	0.2666	0.2428	0.16
13	0 57 46.08	49 10 50.6			
14	0 58 28.63	49 21 38.4			
15	0 59 8.71	49 32 12.9	0.2749	0.2452	0.15
16	0 59 46.26	49 42 34.0			
17	1 0 21.26	49 52 41.6			
18	1 0 53.71	50 2 35.7	0.2831	0.2474	0.14
19	1 1 23.57	50 12 16.1			
20	1 1 50.82	50 21 42.8			
21	1 2 15.46	50 30 55.6	0.2912	0.2494	0.14
22	1 2 37.44	50 39 54.4			
23	1 2 56.76	50 48 39.1			
24	1 3 13.43	50 57 9.5	0.2991	0.2513	0.13
25	1 3 27.41	51 5 25.2			
26	1 3 38.70	51 13 26.3			
27	1 3 47.29	51 21 12.8	0.3069	0.2529	0.12
28	1 3 53.17	51 28 44.0			
29	1 3 56.36	51 35 59.7			
30	1 3 56.87	51 43 0.1	0.3146	0.2544	0.12
31	1 3 51.67	51 49 44.8			
Aug. 1	1 3 49.78	51 56 13.5			
2	1 3 12.21	52 2 26.2	0.3221	0.2558	0.12
3	1 3 31.94	52 8 22.5			
4	1 3 19.01	52 14 1.9			
5	1 3 3.41	52 19 24.6	0.3294	0.2571	0.11
6	1 2 45.16	52 24 30.1			
7	1 2 24.28	52 29 18.2			
Aug. 8	1 2 0.76	+52 33 48.7	0.3367	9.2584	0.11

The brightness on March 7 is taken as unity.

Observatory of State University, Columbia, Mo., 1892 *June* 24.

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*Printed in a Supplement issued with No. 270.

A DEVICE FOR ELIMINATING REFRACTION IN MICROMETRIC OR PHOTOGRAPHIC MEASURES.

By S. C. CHANDLER.

It may be worth while to point out a method by which the effect of differential refraction may be mechanically eliminated from the results of micrometric observation, or the measurements of photographic plates. To say that a device is possible by which an error may be introduced into such measures, which shall nearly compensate the distortions produced by the atmosphere, may seem at first to be paradoxical; but I think that the following will show that this can be done simply and effectively, and that the matter is not one simply of curiosity, but possesses practical interest, in view of the great labor of computing the differential refractions, when there are many stars upon the plate.

Let s and p be the distance and position-angle of a star, as measured from a central star, in the focal plane of the telescope. Let s' and p' be the corresponding values, as measured in a plane slightly inclined to the focal plane; the angular deviation of the plane being c, and the position-angle of the line of intersection of the two planes being γ. Further, let β be the small angle between the lines drawn from the central star to the position of the other on both planes. We then have the approximate relations,

$$\begin{aligned} \tan\beta &= \tan c \sin(p-\gamma) \\ s &= s' \cos(\beta+s) \sec s \\ \cot(p'-\gamma') &= \cos c \cot(p-\gamma) \end{aligned}$$

where γ' is the angle on the assumed plane corresponding to γ on the focal plane.

Since c and β are small, we find, neglecting third and higher powers in the development, and putting

$$f = s^2 c \sin^2 1''$$

$$(1) \qquad \begin{aligned} s - s' &= -s \frac{c^2}{2} \sin^2 1'' \sin^2(p-\gamma) - f \sin(p-\gamma) \\ p - p' &= -\frac{c^2}{4} \sin 1'' \sin 2(p-\gamma) + \gamma - \gamma' \end{aligned}$$

which are the corrections to be applied to the distance and angle measured on the assumed plane to reduce them to the focal plane. Now, make the line of intersection of the two planes horizontal, so that $\gamma = 90° + q$; and make

$$(2) \qquad c = \sqrt{2\kappa} \tan\zeta \operatorname{cosec} 1''$$

where q and ζ are the true parallactic angle and zenith-distance of the central star, and κ is the corresponding constant of differential refraction. The equations (1) then become,

$$(3) \qquad \begin{aligned} s - s' &= -s\kappa \tan^2\zeta \cos^2(p-q) + f \cos(p-q) \\ p - p' &= \kappa \operatorname{cosec} 1'' \tan^2\zeta \cos(p-q) \sin(p-q) + \gamma - \gamma' \end{aligned}$$

But the corrections for differential refraction are

$$\begin{aligned} \sigma - s &= s\kappa[\tan^2\zeta \cos^2(p-q) + 1] \qquad (4) \\ \pi - p &= -\kappa \operatorname{cosec} 1''[\tan^2\zeta \cos(p-q) \sin(p-q) \\ &\qquad + \tan\zeta \sin q \tan\delta] \end{aligned}$$

subject to a remark to be made further on. The addition of the second of (3) and (4) gives

$$\pi - p' = -\kappa \operatorname{cosec} 1'' \tan\zeta \sin q \tan\delta + \gamma - \gamma' \qquad (5)$$

which is the same for all stars on the plate; consequently it will disappear, the zero of position-angle being determined from the apparent motion. To make this evident, put $p' = p = 270°$, in the third of the fundamental formulas in the beginning of this article, and we have, developing,

$$\gamma - \gamma' = \Delta p' = \frac{c^2}{4} \sin 1'' \sin 2\gamma$$

as the correction to the zero of position-angle due to inclination of the plate. Making the same substitutions as before, *i.e.*, $\gamma = 90° + q$, and c as in eq. (2), this becomes,

$$\Delta p' = -\kappa \operatorname{cosec} 1'' \tan^2\zeta \sin q \cos q$$

But we have as the correction for zero of position-angle due to refraction, *i.e.*, for difference of true and apparent diurnal motion,

$$\Delta p = \kappa \operatorname{cosec} 1''[\tan^2\zeta \sin q \cos q + \tan\zeta \sin q \tan\delta]$$

consequently,

$$\Delta p' + \Delta p = \kappa \operatorname{cosec} 1'' \tan\zeta \sin q \tan\delta$$

which, inserted in to (5), gives

$$\pi - p' = 0$$

We thus have the singular result that the position-angles of stars measured on a plate inclined in a vertical direction to the focal plane, by the angle c, eq. (2), will be entirely free from the effect of differential refraction.

The distances, on the contrary, will require a small correction. Thus, adding the first of (3) and (4), we have $\sigma - s' = s\kappa + f \cos(p-q)$, which is very simply computed, f being taken from a table like that below. If the screw-revolution is determined from the plate, the first term of course disappears.

One point is to be noted. The values of q and ζ are assumed to be those for the center of the plate; but in (4) they should be taken for the middle points between the stars. I have elsewhere shown (*A.J.* X, p. 175) that the corrections

to reduce to the proper values are very simple. Thus, if we put $g = -\sin 1'' \sec \zeta \cos(p-q)$, we have.

$$l(\sigma - s) = s(\sigma - s)\,g \quad . \quad l(\pi - p) = s(\pi - p)\,g$$

These corrections are ordinarily very small, and may be interpolated from a few values computed for different parts of the plate.

It may be objected that the above device will affect the stellar images; but attentive examination will show. I think, that the differences of definition will be inappreciable.

The following table gives an idea of the value of c and f for various zenith-distances. It is computed with Bessel's mean refractions.

ζ	c	f s = 400″	800″	1200″	1600″	2000″	2400″
	″	″	″	″	″	″	″
10	0.24	0.00	0.01	0.03	0.05	0.08	0.12
20	0.49	.01	.03	.06	.11	.17	.24
30	0.78	.01	.04	.09	.17	.26	.38
40	1.13	.02	.06	.14	.21	.38	.55
45	1.35	.02	.07	.16	.29	.45	.65
50	1.61	.02	.09	.19	.31	.54	.78
55	1.92	.03	.10	.23	.41	.65	0.93
60	2.33	.03	.12	.28	.50	.79	1.14
65	2.88	.04	.15	.35	.62	0.97	.40
70	3.66	0.05	0.20	0.41	0.79	1.24	1.79

It is unnecessary to indicate the obvious and simple mechanical contrivances by which this method may be applied.

SUNSPOT OBSERVATIONS,

MADE AT THE HAVERFORD COLLEGE OBSERVATORY WITH 8-INCH EQUATORIAL.

By W. H. Collins.

1892	Time	Grs	Spots	Fac Grs	Def. and Size
Jan. 1	2	5	42	0	bad
2	1	5	49	0	poor
3	2	7	71	1	good : 2 lar
4	9	6	56	1	fair ; 3 lar
5	11	5	46	1	poor ; 2 lar
7	9	3	26	0	poor ; 1 lar
8	10	3	40	1	good ; 2 lar
9	12	3	20	0	poor
16	10	6	45	0	fair
17	10	8	34	1	bad
20	3	7	48	1	fair ; 1 lar
21	9	7	43	1	bad : 1 lar
22	11	9	97	2	v.g. ; 2 lar
23	9	8	81	1	fair ; 2 lar
25	10	5	26	1	bad : 2 lar
26	1	5	19	1	bad : 2 lar
27	10	4	17	0	poor : 2 lar
28	12	4	19	2	bad : 1 lar
31	10	6	19	1	fair ; 1 lar
Feb. 1	11	6	44	1	fair : 1 lar
2	3	5	12	0	bad
4	9	6	27	0	poor
5	8	6	32	0	bad
6	10	5	49	2	poor
8	10	4	72	1	fair : 2 lar
9	9	3	94	3	good ; 3 lar
10	10	2	80	0	fair ; 3 lar
11	2	5	171	2	good : 2 lar
12	5	1	59	0	bad
13	10	1	89	2	bad ; 3 lar
14	10	5	145	1	good ; 2 lar
15	10	7	169	0	good : 2 lar
16	11	7	121	0	poor : 2 lar
17	10	7	97	0	poor : 2 lar
18	10	9	95	1	fair : 1 lar
19	11	9	56	1	poor
22	11	5	21	0	bad
23	2	4	14	0	poor
27	9	2	8	1	poor
Mar. 3	10	3	18	2	fair
4	10	4	17	1	fair
Mar. 6	10	3	22	1	fair
7	12	1	12	1	fair
9	10	2	32	0	fair
11	10	3	32	1	poor
12	10	4	37	1	fair
14	11	4	32	0	poor
15	10	3	10	0	poor
16	1	2	8	0	bad
19	10	4	35	2	good
20	9	5	52	2	good ; 1 lar
21	9	7	49	3	fair ; 1 lar
22	9	6	49	1	poor ; 1 lar
24	9	7	78	1	fair : 2 lar
25	9	6	65	0	fair ; 2 lar
28	10	8	61	2	fair
29	11	6	55	1	fair
30	10	6	25	2	poor
Apr. 1	10	5	14	3	poor : 1 lar
3	10	5	22	1	poor ; 1 lar
4	10	2	2	2	bad : 1 lar
6	10	5	15	5	poor
8	9	6	27	2	fair : 3 lar
9	9	5	18	2	fair ; 3 lar
10	9	5	20	1	poor : 1 lar
11	9	6	35	2	fair : 2 lar
12	10	7	60	1	poor : 1 lar
13	10	5	42	1	poor : 1 lar
15	3	4	16	1	bad ; 1 lar
16	9	4	27	3	poor : 1 lar
19	9	5	46	2	poor : 1 lar
20	10	4	60	1	fair : 1 lar
23	10	10	193	3	fine
24	9	8	194	1	fine ; 4 lar
28	10	5	37	0	bad
29	6	6	36	1	good : 2 lar
30	9	7	36	3	good : 2 lar
May 1	9	5	32	2	fair ; 3 lar
2	9	7	46	1	poor : 4 lar
3	9	6	79	1	fair : 4 lar
4	10	7	35	1	bad : 5 lar
5	10	8	35	1	poor : 4 lar
May 6	10	6	21	0	bad ; 3 lar
7	9	6	31	1	poor ; 3 lar
8	9	5	21	2	fair ; 1 lar
9	9	5	16	3	fair ; 3 lar
10	8	7	20	1	good ; 3 lar
11	1	4	28	2	fair ; 2 lar
12	3	5	28	2	fair ; 1 lar
13	1	5	23	0	poor ; 2 lar
16	11	3	34	3	poor : 1 lar
17	9	2	43	2	fair ; 1 lar
18	9	3	58	2	fair ; 2 lar
20	9	3	18	0	poor
23	9	7	48	2	poor ; 2 lar
24	10	7	57	3	fair : 3 lar
25	10	7	65	3	fair ; 4 lar
26	9	6	73	4	good ; 2 lar
27	9	7	88	2	good ; 4 lar
28	9	8	100	1	poor ; 3 lar
29	10	7	125	1	fair
30	11	6	135	1	good : 2 lar
June 1	9	8	106	1	fair ; 3 lar
2	10	7	78	1	poor ; 3 lar
3	10	5	19	1	bad ; 3 lar
9	3	5	23	2	poor
11	10	5	31	1	poor
12	9	5	32	2	poor : 2 lar
13	10	7	55	2	fair : 2 lar
14	10	6	45	1	fair ; 2 lar
15	10	6	35	1	poor ; 2 lar
16	2	5	65	1	fair ; 1 lar
17	10	6	92	1	good ; 3 lar
18	9	6	68	0	fair ; 6 lar
19	1	4	56	1	fair : 2 lar
20	10	7	105	4	fair : 5 lar
21	9	7	161	2	good : 5 lar
22	9	7	115	1	fair : 8 lar
23	1	5	31	1	bad
24	9	6	50	1	poor ; 2 lar
25	11	5	46	0	bad : 1 lar
26	10	6	34	3	fair : 1 lar
27	11	4	18	0	poor

SUNSPOT OBSERVATIONS,

MADE AT PHILADELPHIA, PENN., WITH A 4.5-INCH REFRACTOR.

BY A. W. QUIMBY.

1892	Time	New Grs.	New Sps.	Total Grs.	Total Sps.	Fac. Grs.	Def.
Jan. 1	2	–	–	5	44	–	poor
2	1	–	–	5	83	3	poor
3	2	–	–	5	43	3	poor
4	10	–	–	4	44	3	poor
5	11	1	3	5	37	3	poor
7	11	1	4	4	34	1	fair
8	1	–	–	3	26	2	good
9	2	–	–	3	22	2	fair
13	10	1	1	2	2	–	v. poor
14	2	2	6	4	14	–	poor
15	11	–	–	3	–	–	v. poor
16	10	2	–	6	58	3	fair
17	1	1	2	7	101	3	good
20	11	1	–	8	58	3	fair
21	9	–	–	8	48	4	fair
22	12	2	–	9	64	1	fair
23	12	–	–	7	48	4	fair
24	1	–	–	6	27	3	poor
25	12	–	–	6	36	3	fair
26	9	–	–	5	19	3	poor
27	10	–	–	4	9	3	poor
28	9	–	–	4	7	3	poor
30	9	4	9	6	15	4	poor
31	9	2	6	9	25	5	fair
Feb. 1	10	–	–	6	25	3	poor
2	3	–	–	6	31	–	poor
3	3	–	–	3	27	6	poor
4	9	1	4	1	37	4	fair
5	5	1	15	6	35	–	poor
6	9	1	5	5	41	3	poor
7	8	–	–	1	14	–	v. poor
8	10	–	–	4	191	5	good
9	10	–	–	1	186	4	poor
10	10	1	2	2	121	3	poor
11	5	1	7	4	191	3	poor
12	12	–	–	1	173	3	poor
13	10	1	27	7	103	4	poor
14	10	1	1	8	221	3	fair
15	10	1	3	9	176	3	fair
16	9	–	–	9	85	2	poor
17	10	–	–	9	77	3	poor
18	9	1	4	9	102	2	fair
19	9	1	1	9	37	2	v. poor
22	12	–	–	5	35	3	poor
23	3	1	1	4	36	1	poor
24	12	–	–	4	17		poor
25	12		–	2	5	2	v. poor
26	12	1	1	2	9	3	poor
27	12	–	–	2	7	2	poor
Mar. 3	10	1	2	3	15	2	poor
4	11	2	3	4	20	5	fair
5	12	–	–	2	5	–	v. poor
7	9	–	–	3	21	11	fair
8	5	–	–	1	–	–	–
9	7	1	1	2	21	–	poor
10	7	–		2	56	–	poor
Mar. 11	9	–	–	2	35	–	poor
12	8	2	2	5	73	3	fair
13	9	–	–	3	31	–	v. poor
14	9	2	2	5	34	–	poor
15	9	–	–	6	23	5	poor
16	1	–	–	6	17	5	poor
17	9	1	–	2	–	–	v. poor
19	3	1	3	4	41	5	fair
20	9	1	3	5	41	6	good
21	10	1	1	6	49	5	fair
22	10	–	–	6	79	7	fair
24	9	1	7	7	109	4	good
25	9	–	–	6	114	1	good
26	10	–	–	8	64	1	poor
28	10	1	3	7	57	4	fair
29	10	–	–	7	41	7	fair
30	10	1	1	6	29	1	poor
Apr. 1	9	1	–	4	16	2	poor
2	9	–	–	3	11	3	poor
3	9	–	–	3	21	2	fair
4	10	–	–	3	7	2	fair
5	7	1	1	4	8	–	v. poor
6	10	–	–	5	14	4	poor
8	9	–	–	4	21	6	poor
9	1	–	–	3	8	3	poor
10	9	2	3	5	11	3	poor
11	9	–	–	5	16	3	poor
12	9	1	7	6	39	3	poor
13	8	–	–	5	14	4	fair
14	8	–	–	1	–	–	
15	8	1	7	5	21		fair
16	8	–	–	3	20	1	good
17	2	1	9	4	35	4	poor
19	8	–	–	5	77	4	[illegible]
20	8	–	–	4	76	3	[illegible]
23	7	5	–	10	278	2	[illegible]
24	8	1	–	10	313	5	[illegible]
25	10	–		8	150		[illegible]
26	8		–	5	215	4	[illegible]
27	8	1	–	5	[illegible]	4	[illegible]
28	8	1		6	47	[illegible]	
29	6	1	6	7	[illegible]	[illegible]	[illegible]
30	7	1	–	8	[illegible]		
May 1	9	–		[illegible]	25		[illegible]
2	8		–	8	82		
3	8			7	128		
4	8	1		8	[illegible]		
5	7	–	–	7	[illegible]		
6	7	–		6	8	[illegible]	
7	7		–	6	[illegible]	2	
8	8	1		5	[illegible]	[illegible]	
9	8			5	[illegible]		
10	8	2	2	7	15	[illegible]	[illegible]
11	3	–		5	57	4	
12	10	1	1	5	73	4	[illegible]
13	8			[illegible]	[illegible]	[illegible]	[illegible]

1892	Time	New Grs.	New Sps.	Total Grs.	Total Sps.	Fac. Grs.	Def.
May 15	8	1	–	4	51	2	fair
16	8	–	–	4	58	4	fair
17	7	–	–	3	76	2	good
18	8	1	3	4	37	–	poor
20	8	1	–	5	27	2	poor
21	12	–	–	3	13	–	v. poor
22	7	1	–	7	57	–	poor
23	10	1	–	7	53	2	poor
24	8	–	–	7	119	4	fair
25	8	–	–	7	86	4	fair
26	8	2	–	6	82	4	fair
27	9	1	–	8	104	3	poor
28	7	–	–	7	73	2	poor
29	8	1	2	7	101	3	fair
30	8	–	–	5	120	–	poor
31	10	–	–	5	123	2	fair
June 1	7	1	2	7	152	–	fair
2	8	–	–	7	71	3	fair
3	9	–	–	4	38	–	poor
5	8	1	–	5	10	–	poor
6	8	1	1	5	12	3	poor
7	8	1	1	4	6	2	poor
8	8	–	–	5	8	3	poor
June 9	2	1	1	5	21	2	poor
10	3	–	–	5	33	2	poor
11	7	–	–	6	51	3	fair
12	9	–	–	5	17	3	fair
13	7	5	9	9	37	3	fair
14	7	–	–	9	26	2	poor
15	7	–	–	9	34	3	poor
16	3	–	–	8	43	2	fair
17	10	–	–	9	111	3	fair
18	7	2	3	12	101	3	poor
19	4	–	–	9	114	2	poor
20	7	–	–	8	99	4	poor
21	–	–	–	7	71	4	fair
22	7	1	–	9	77	2	fair
23	7	1	–	7	47	3	poor
24	7	–	–	8	39	2	poor
25	7	–	–	6	33	1	poor
26	8	2	–	9	37	2	poor
27	8	–	–	5	28	1	poor
28	2	1	–	5	23	2	fair
29	8	–	–	4	12	4	poor
30	8	–	–	3	10	5	fair

OBSERVATIONS OF COMETS,

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 9-INCH EQUATORIAL.

By Prof. E. FRISBY.

[Communicated by the Superintendent.]

1892 Washington M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
Comet *b* 1892 (Periodic of Winnecke).								
d h m s			m s	' "	h m s	° ' "		
June 15 11 0 39.7	1	20 , 4	+1 40.26	—0 32.4	10 19 35.56	+41 0 48.5	9.770	0.668
17 11 19 54.5	2	20 , 4	+1 21.59	—6 37.4	10 11 19.82	+40 28 27.1	9.768	0.723
25 11 32 3.5	3	10 , 2	—3 9.75	—0 8.3	9 22 11.30	+36 48 55.3	9.726	0.770
29 9 19 16.0	4	15 , 3	—3 46.41	—3 25.7	8 41 31.94	+33 5 58.4	*n*9.519	0.760
Comet *a* 1892 (Swift).								
June 15 11 9 52.8	5	5 , 1	—1 56.74	+0 34.5	0 22 15.12	+42 32 50.2	*n*9.762	0.765
17 11 54 28.8	6	13 , 3	—0 4.78	+0 53.8	0 26 11.72	+43 7 43.2	*n*9.791	0.691
29 10 6 50.2	7	15 , 3	—3 47.43	+1 34.5	0 43 56.38	+46 17 2.2	*n*9.758	0.803

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ' "	"	
1	10 17 54.86	+0.44	+41 1 10.2	+10.7	Bonn VI, 41° 2082
2	10 9 57.88	+0.35	+40 34 53.9	+10.6	Weisse-Bessel X, 153
3	9 25 21.03	+0.02	+36 48 54.4	+ 9.2	Bonn VI, 36° 1970
4	8 48 18.51	—0.16	+33 9 15.9	+ 8.2	Leiden Zones, 16. 47; 165, 96
5	0 24 11.86	0.00	+42 32 24.9	— 9.2	Bonn VI, 42° 89
6	0 26 19.62	—0.12	+43 6 58.5	— 9.1	Bonn VI, 42° 96
7	0 47 43.48	+0.33	+46 15 35.3	— 7.6	Bonn VI, 46° 193

THE NEW BINARY, β 639.

By S. W. BURNHAM.

In 1878, when observing with the 18½-inch refractor of the Dearborn Observatory, I found that the principal star of the wide pair observed by SOUTH and HERSCHEL in 1823 was a close double. In 1871 I had detected with the Washington 26-inch a very faint companion to the smaller component of the wide pair, but did not notice the close pair. The motion seems to be very rapid, and this may explain my failure to see it with the more powerful instrument. Last year (1891) there was no certain elongation with the 12-inch of the Lick Observatory, and more recent examination with the 36-inch shows that this star is absolutely round, with all powers under favorable conditions. It is clearly a binary of short period, but unfortunately we have but two sets of measures, and these are insufficient to give any idea of the probable period.

The following is a complete list of all the measures of the several components:

A AND *B* (β 639).

1878.66	155°.3	0″.57	7.2 . . 7.7	Burnham	2*n*
1883.12	137.9	0.35	7.5 . . 7.5	Schiaparelli	2*n*
1891.65	Single, 12-inch		. .	Burnham	
1892.36	Single, 36-inch		. .	Burnham	

C AND *D* (β 300).

1891.65	325.5	8″.30	. . 13.5	Burnham	2*n*

A, *B* AND *C* (Sh. 264).

1823.15	52°.6	16″.42	7 . . 8	Herschel	1*n*
1862.72	51.5	16.83	7.2 . . 8.7	Hall	1*n*
1877.60	52.2	17.37	7.2 . . 8.0	Cincinnati	2*n*
1878.66	51.7	17.30	. . 8.0	Burnham	2*n*
1879.27	51.1	17.10	6.0 . . 8.0	Cincinnati	1*n*
1883.29	51.3	17.15	. . 8.0	Schiaparelli	3*n*
1890.50	51.2	17.67	7.2 . . 7.7	Glasenapp	2*n*
1891.65	52.4	17.21	7.1 . . 7.7	Burnham	2*n*

There has been no material change in the relative positions of the bright stars. The principal component is Lalande 33642. Both stars are given in the Argentine Catalogue, the respective magnitudes being 7¼ and 8. They probably form only an optical pair. The star-catalogues do not give any proper motion. The close pair should be watched until it becomes again measurable. The secondary will then be probably in the first quadrant.

OCCULTATION OF *MARS*, 1892 JULY 11.

By A. HALL.

[Communicated by Capt. F. V. McNAIR, Superintendent.]

Phase	Washington M.T.	Remarks
First contact	11h 3m 58s.5	fair, thin clouds
Second "	11 4 59.5	fair, thin clouds
Third "	12 7 56.5	uncertain, cloudy
Fourth "	12 9 5.5	fair

The preceding observations were made with the 9.6-inch equatorial, power 132. The observations were made through openings in the clouds, and on account of the misty condition of the sky nothing could be inferred concerning an atmosphere of the planet.

Naval Observatory, 1892 *July* 12.

NUMERATION OF THE ASTEROIDS.

An excellent arrangement has been agreed upon for avoiding confusion in the numeration of asteroids which may hereafter be discovered. Professor KRUEGER will assign to them a provisional notation (1892 *A*, *B*, *C*, etc.) arranged in the order of their announcement to the "*Telegraphische Central-Stelle*"; and the definite numeration will be subsequently undertaken by Prof. TIETJEN; Director of the *Rechen-Institut* in Berlin. In this definite assignment of numbers, those planets will be omitted for which sufficient material is not available for a determination of the orbits.

All danger of confusion appears to be avoided by this arrangement; and even those asteroids, which, for want of sufficient observations, may fail of receiving numbers at first, will always be easily recognizable by their letters in the annual series. It can scarcely be doubted that this solution of the existing embarrassment will receive general acceptance.

NEW ASTRONOMICAL WORKS.

Der Brorsen'sche Comet. I. Theil. Die Verbindung der Erscheinungen 1873 und 1879 und die Vorausberechnung für 1890. Von Prof. Dr. E. LAMP. Kiel, 1892. 68 pp. 4to.

This memoir forms part VII of the publications of the Kiel Observatory. The comet of which it treats is, for various reasons, one of the most interesting of the short-period class, and furnishes one of the most puzzling problems, yet unsolved, in this branch of astronomy. Although its rediscovery in 1884 and 1891 was certainly expected, an earnest search for it by many observers and under very favorable circumstances on the latter occasion, was unsuccessful. The present publication of the details of LAMP's investigations seems to show that the reason for the failure does not

lie in the accuracy of his elements, and leads us to suspect the existence of some cause therefor connected with the comet itself.

Originally discovered in 1846, the return in 1851 went unobserved. When accidentally rediscovered in 1857, it was found that errors in the calculation of the elements and perturbations had falsified the orbit. A new computation by BRUHNS led to its being refound by him in 1868. The orbit was then brought forward to 1873 by PLUMMER, and also by SCHULZE, and by the latter to 1879, on both of which occasions it was observed. SCHULZE, however, found it impossible to reconcile the discordances in the times of revolution given by the three last appearances; but, notwithstanding that his orbit, on which HIND's finding ephemeris for 1884 was based, proves to have been reasonably correct, according to LAMP's present results, the comet eluded observation at that return.

Dr. LAMP's work began in 1889. His experience, in the attempt to unite the three appearances, was like that of SCHULZE; and a repetition of the latter's calculation by him, with an arbitrary change in the mean motion, showed no marked correction of SCHULZE's results. Uniting the 1873 and 1879 appearances, and carrying the perturbations by *Jupiter* and *Saturn* to 1890, he provided a finding ephemeris for that return; but again the comet could not be seen.

Must we then assume that the comet had dissolved and disappeared? Or was LAMP's calculation incorrect? Or did the trouble arise from an intensified variation of the intrinsic brightness, like what had characterized it on previous occasions? In this connection some peculiarities of the orbit are to be noticed, principally its proximity, at ascending node, to *Venus's* orbit, and at descending node to that of *Jupiter*. As is known from HARZER's work, the comet had, in 1842, come within 0.05 of *Jupiter*, and been thrown into its present orbit. LAMP shows, also, that the orbit approaches very closely to those of the asteroids *Hebe*, *Hesperia* and *Artemis*, but he thinks we must look first to other possible causes for the explanation of the discordances in the times of revolution. After presenting considerations as to the possible effect of a resisting medium, and also with regard to the comet's remarkable variations in brightness and dimensions, he concludes that we have no means, from any observable relations of the so-called theoretical brightness with the actual brightness, for inferring any explanation of the comet's nonvisibility in 1890.

The discussion of the orbit from the observations of 1873 and 1879 is then presented. The perturbations for the appearance of 1879 were computed, for the rectangular coordinates, taking account only of *Venus*, *Earth* and *Jupiter*, the action of the other planets being unimportant. Between 1873 and 1879 the method of variation of constants was used, for the especial advantage of more convenient comparison with SCHULZE's work; *Mars*, *Saturn* and *Mercury* being also included, the last in part directly, in part by reference to its common center of gravity with the sun. With the resulting elements for 1873 and 1879, and the perturbations of *Jupiter* and *Saturn* brought forward to 1890, (the differential coefficients being developed according to the true anomaly instead of the time, and the computation controlled by a direct calculation for those of *Jupiter*) the definitive elements for the unobserved returns of 1884 and 1891 are established. A comparison of these with the finding ephemerides used on those occasions shows that the failure in seeing the comet, especially in the latter year, when the circumstances were favorable, cannot be attributed to error of calculation. The problem of nonvisibility therefore remains an unsolved one.

The RUTHERFURD *Photographic Measures of the Group of the Pleiades, by* HAROLD JACOBY. New York, 1892. 92 pp. 8vo.

This memoir constitutes No. 3 of the Contributions from the Observatory of Columbia College, and contains the reduction of RUTHERFURD's photographs of the *Pleiades*, made in 1872 and 1874. The series comprises ten plates, each having a double impression, so that there are in general twenty position angles and distances of each of the 75 stars measured. The division errors of the scale of the measuring apparatus were determined by Prof. W. A. ROGERS, previous to the reductions. The scale-value was made to depend on BESSEL's and ELKIN's heliometer measures of six moderately bright stars of the group, symmetrically situated in direction from *24 p*, the central star, and widely distant, but not too near the edge of the plates.

The last of the nine sections of the paper gives a comparison of the results with the Königsberg and Yale heliometer values in the form of differences of right-ascension and declination. The high degree of accuracy attainable by the photographic method is thus favorably shown. The photographic measures appear to accord with those of the heliometer as well as the latter do among themselves. This precision gives flattering promise of highly valuable results to astronomy from the reduction of the plates pertaining to the large number of other clusters photographed by the lamented RUTHERFURD. All of these plates have, it is believed, been placed in the hands of the Director, Prof. J. K. REES, for similar treatment.

Mesures D'Étoiles Doubles faites à Hoursouf par Prof. S. de GLASENAPP. St. Petersbourg, 1892. 68 pp. 8vo.

These observations are the results of an expedition to the southern part of Russia, near Jalta, on the Black Sea, in 1890, for the purpose of making measures of southern binaries, inaccessible at St. Petersbourg, and of which measures were much needed. The instrument used was by the REPSOLDS, of 160mm aperture, the power habitually employed being 267. The measurements comprise 435 pairs, besides the cluster 25 *M Sagittarii*. In general two measurements were made of each pair, in both positions of the telescope with reference to the axis.

CORRIGENDA.

No. 268, p. 30, ☄ *a*, May 28.

Apparent α, *for* 23 46 13.45, *put* 23 46 13.69

✶4 Red. to app. place, *for* −0.62 *put* −0.38

No. 269, p. 37, col. 1. The following paragraph should be inserted after equation (3): —

Now for equivalent diameters of the images formed by two different telescopes, whose apertures are Q_0 and nQ_0, the difference between equations (2) and (3) for the same t will be a constant whose value is given by the equation

$$m'_n - m'_0 = 5 \log n \tag{4}$$

consequently

$$m'_n = m'_0 + 5 \log n \tag{5}$$

No. 270, p. 43, col. 1, λ *Tauri* October 25. Least observed light, *for* $4^M.23$ *put* $4^M.13$. The times of equal light given were for $4^M.0$, $4^M.05$, and $4^M.10$.

CONTENTS.

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ON THE VARIATION OF LATITUDE.

BY S. C. CHANDLER.

VI.

Before going further with the discussion of the results,* it comes more conveniently in order, to present the details for the forty-five series of Table I, as promised on p. 17. To save repetition I must refer to Vol. XI, pp. 66–70, for explanation and illustration of the manner of arranging the data for solution, and to no. 267, pp. 17 and 18, for the formulas and method of solution employed. Some further general explanation is also required.

In beginning the computations it was intended to reduce everything to NYRÉN's aberration-constant, 20″.495, as the one now generally accepted. Afterwards a doubt arose in my mind (see XI, p. 69), which subsequent investigation has tended to confirm, whether STRUVE's value is not more nearly correct, and I accordingly reverted to the latter, in all series subsequently treated. This slight want of uniformity in the basis of discussion is, however, of slight consequence, as the elements of the latitude-variation deduced from most of the series are not much dependent on the particular value of the aberration-constant used.

There is also a want of uniformity in the values of θ assumed in the different series. This was unavoidable, from the nature of the case. Thus, in the beginning, while I was at work on the interval 1860–1890, the value 0°.843 was used, corresponding to $P = 427^d$. But as soon as the fact of the lengthening of the period became manifest, I adopted, in the subsequent discussions, various values, corresponding to the epochs as nearly as I could at that time guess at the law of the variation. Here also, however, as in the case of the aberration-constant, the effect of errors in the assumed values is in general unimportant, as regards the values of r and T' found from the solutions. Wherever I had reason to suppose that this was not the case, new solutions were made. Entire consistency in this particular was not sought after, since a definitive investigation would require other changes and additions, and at this stage it was not desirable to spend too much time upon merely subordinate corrections.

In the tables which follow, the first two columns contain the calendar dates, and the last four places of the corresponding Julian dates, of the groups in each series, after the observations had been collected from the authorities, corrected as described in the special explanations accompanying each series below, and arranged within the limits of one period, as exemplified in the Pulkowa observations, *A. J.* XI, p. 66–68; where the process is described fully. To save printing, the values of $\Delta\varphi$ derived directly from the observations are not given; but in their stead, these values after subtracting the constant correction, x, of the arbitrary assumed mean latitude, φ'_0. This value of $\Delta\varphi$ is the one given in the fourth column, O, of the tables below. From eq. (8) it is the quantity $n - x = \varphi - \varphi'_0$. The values of n used in the solutions can therefore be reproduced, if desired, by adding the values of x given at the foot of each series, to the column O. Thus in series XVII, for example, by adding $x = -0''.01$ to the fourth column, we get the values given in column 12 on p. 66, Vol. XI. The fifth column, C, contains the value computed from the equation in the last line, first column of p. 18, using r and T' as in Table I, and the assumed value of θ hereunder given for each series. The sixth column, C', gives the computed values according to the general law of equation (2), (3) and (4).

Following the above described quantities for each series, are the normal equations formed from the observation-equations according to eq. (9). At the right of these, after the vertical rule, are the resultant values of x, y and z. These values, by eq. (10) and (7), give the r and T' of Table I.

In general the equations of each series were given equal weight; but, where the number of observations was very unequal, they were weighted as indicated in parentheses

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* When this discussion is resumed, in the article following this, it will be seen that I have examined the topics touched upon by Prof. NEWCOMB in no. 271, and that what appears to me a completely satisfactory answer is afforded to the objections raised by him. Notwithstanding its conflict with theory, the variation of the period seems to me to be as well proved as the existence of the 427-term itself.

added to the third column, which contains the number of observations.

I. *Greenwich Reflex Zenith-Tube Observations of γ Draconis*, 1837–48. (From MAIN's paper in the *Memoirs R.A.S.*, XXIV.) Reduced to NYRÉN's aberration-constant. Assumed $\theta = 0^\circ.986$; $T'_0 = 239\,3880$.

1842	*t*	Obs.	*O* ″	*C* ″	*C′* ″
Jan. 15	3851	21	+0.07	—0.51	—0.24
Feb. 14	3881	8	—1.07	— .57	— .16
Mar. 15	3910	37	—0.80	— .49	— .08
Apr. 15	3941	68	— .17	— .27	+ .01
May 15	3971	55	— .08	+ .01	+ .12
June 15	4002	87	+ .61	+ .30	+ .20
July 15	4032	85	+ .57	+ .50	+ .22
Aug. 15	4063	126	+ .55	+ .57	+ .17
Sept. 15	4094	86	+ .45	+ .18	+ .09
Oct. 15	4124	36	— .20	+ .27	— .01
Nov. 15	4155	35	— .01	— .02	— .12
Dec. 15	4185	42	+0.03	—0.30	—0.20

$$\begin{array}{rrrcl} 12\;x & -0.01\,y & +0.07\,z & = & +2''.23 \\ -0.01 & +5.97 & +0.03 & = & +0.06 \\ +0.07 & +0.03 & +6.01 & = & -3.40 \end{array} \qquad \begin{array}{l} x = +0''.189 \\ y = +0.013 \\ z = -0.568 \end{array}$$

II. STRUVE's *Prime-Vertical Observations*, 1840–44. This is one of the two exceptions mentioned on p. 17, for which the treatment was not entirely homogeneous with that of the others. The values of *r* and *T′* on p. 18 were derived, not by a least-square solution in this case, but by a graphical treatment of five of the seven stars (*b Draconis* and *2 H Cephei* not used); pending a definitive discussion not yet completed.

1841–2	*t*	Obs.	*O* ″	*C* ″	*C′* ″
Sept. 22	3736	22	+0.07	+0.08	+0.13
Oct. 18	3762	29	+ .10	+ .07	+ .04
Nov. 23	3798	15	— .01	+ .03	— .08
Jan. 9	3845	23	— .04	— .03	— .20
Feb. 23	3890	17	— .07	— .08	— .20
Apr. 6	3932	18	— .14	— .07	— .11
May 2	3958	28	+ .03	— .05	— .03
June 5	3992	34	— .03	— .01	+ .10
July 1	4018	56	+ .05	+ .03	+ .17
Aug. 12	4060	28	+0.04	+0.06	+0.21

III. *Radcliffe Meridian-Circle Observations of Polaris*, 1840–44. (From the annual volumes.) Reflected observations not used. Assumed $\theta = 0^\circ.960$; $T'_0 = 239\,1200$.

1842	*t*	Obs.	*O* ″	*C* ″	*C′* ″
Jan. 6	3842	36	—0.27	—0.02	—0.22
Mar. 7	3902	42	+ .38	+ .17	— .12
Apr. 15	3941	18	+ .36	+ .21	+ .04
May 15	3971	14	+ .05	+ .18	+ .13
June 15	4002	26	— .02	+ .11	+ .20
Sept. 15	4094	31	+ .05	— .18	+ .09
Oct. 21	4130	46	— .37	— .21	— .04
Nov. 27	4167	32	—0.03	—0.17	—0.16

$$\begin{array}{rrrcl} 8\;x & +0.57\,y & +0.17\,z & = & +0''.47 \\ +0.57 & +4.38 & 1.06 & = & +0.97 \\ +0.17 & -1.06 & +5.59 & = & -0.47 \end{array} \qquad \begin{array}{l} x = +0''.046 \\ y = +0.197 \\ z = -0.075 \end{array}$$

IV. PETERS's *Vertical Circle Observations for Parallax*, 1842–43. From his values of *n*, p. 108 ff of his memoir not including *Polaris*; applying the values of ξ, p. 122 ff, and values of the parallaxes for the seven stars, modified from his, according to the best modern values. Assumed $\theta = 0^\circ.960$; $T'_0 = 239\,4200$.

1842–3	*t*	Obs.	*O*	*C*	*C′* ″
May 5	3961	45	+0.01	+0.01	0.00
May 27	3983	10	.00	+ .07	+0.18
July 8	4025	52	+ .04	+ .09	+0.19
Aug. 11	4059	45	+ .20	+ .08	+0.22
Sept. 16	4095	42	+ .05	+ .04	+0.17
Nov. 12	4152	48	— .09	— .08	.00
Feb. 21	4256	36	— .07	— .07	— .21
Apr. 3	4294	43	— .01	— .02	— .16
Apr. 27	4318	58	+0.13	+0.02	—0.08

$$\begin{array}{rrrcl} 9\;x & +1.35\,y & -2.53\,z & = & -0''.01 \\ +1.35 & +5.31 & -0.41 & = & -0.11 \\ -2.53 & -0.41 & +3.67 & = & -0.24 \end{array} \qquad \begin{array}{l} x = -0''.025 \\ y = -0.021 \\ z = -0.085 \end{array}$$

V. PETERS's *Vertical Circle Observations of Polaris*, 1842–44. (From NYRÉN's memoir on the Latitude of Pulkowa.) Treated exactly like GYLDÉN's and NYRÉN's similar series, XVII and XXIII. Assumed $\theta = 0^\circ.973$; $T'_0 = 239\,4300$.

1842–3	*t*	Obs.	*O* ″	*C* ″	*C* ″
Oct. 6	4115	40	+0.10	+0.05	+0.12
Nov. 14	4154	38	— .02	+ .04	— .01
Feb. 4	4236	40	— .02	— .03	— .21
Mar. 18	4278	40	— .07	— .05	— .18
Apr. 17	4308	40	— .03	— .06	— .12
May 20	4341	50	+ .02	— .04	.00
June 30	4382	40	— .07	.00	+ .14
Aug. 13	4426	41	— .04	+ .03	+ .21
Sept. 16	4460	43	+0.12	+0.05	+0.20

$$\begin{array}{rrrcl} 9\;x & +1.14\,y & +0.09\,z & = & -0''.25 \\ +1.14 & +3.57 & -0.28 & = & 0.00 \\ +0.09 & -0.28 & +5.61 & = & -0.29 \end{array} \qquad \begin{array}{l} x = -0''.028 \\ y = +0.005 \\ z = -0.051 \end{array}$$

VI. MACLEAR's *Mural Circle Observations of β Centauri, Cape of Good Hope*, 1842–44. (*Memoirs R.A.S.*, XX). These double-altitude observations gave the well known anomalous parallaxes, apparently confirmed by MOESTA at Santiago, but contradicted by the heliometer-determinations of GILL and ELKIN both for this star and *α Centauri*. These discordances are responsible for much of the prevailing distrust of absolute-parallax determinations in general, and the reason for them has up to now remained a mystery. The present investigation, I think, clearly shows the true cause to be the latitude-variation, in the case of *β Centauri*: and the similar anomalies for *α Centauri* will probably also be disposed of when my computation for that star is finished.

Observations here reduced with STRUVE's aberration, $\pi = 0$, and annual proper motion in decl. $-0''.06$. Assumed $\theta = 0^\circ.947$; $T'_0 = 239\,4300$.

1843–4	t	Obs.	O	C	C'
Mar. 28	4288	17	−0.28	−0.28	−0.14
Apr. 30	4321	24	− .34	− .34	− .04
June 15	4367	21	− .23	− .21	+ .12
Sept. 8	4452	16	+ .30	+ .20	+ .20
Nov. 4	4509	15	+ .20	+ .31	+ .04
Jan. 29	4595	24	+ .10	+ .04	+ .21
Feb. 28	4625	17	−0.10	+0.11	+0.21

$$\begin{array}{rrrcrl} 7\ x & -0.47\,y & +1.38\,z & = & -0.11'' & x = +0.033'' \\ -0.47 & +3.00 & -0.31 & = & -0.19 & y = -0.089 \\ +1.38 & -0.31 & +4.00 & = & -1.13 & z = -0.301 \end{array}$$

VII. WEYER's *and* BRÜNNOW's *Prime-Vertical Observations of β Draconis. Berlin*, 1845–46. (Berlin observations, also *A.N.* XXIX.) From his own observations alone, WEYER deduced an anomalous aberration-constant, 20″.255, and a large parallax of a third of a second. ENCKE remarks that BRÜNNOW's later observations do not favor the idea of parallax. The present computation seems to prove that the latitude-variation is responsible for the erroneous results.

Observations reduced to NYRÉN's aberration. Equations weighted according to number of observations. Assumed $\theta = 0°.947$; $T'_0 = 239\,5300$.

1845–6	t	Obs.	O	C	C'
May 27	5079	1	+0.34	+0.18	−0.01
June 18	5101	9	+ .52	+ .25	+ .08
July 12	5125	16	+ .14	+ .28	+ .14
Aug. 21	5165	13	+ .21	+ .24	+ .21
Sept. 12	5187	11	+ .32	+ .18	+ .21
Oct. 12	5217	6	− .11	+ .04	+ .17
Nov. 17	5253	4	− .08	− .11	+ .07
Dec. 25	5291	2	− .34	− .24	− .07
Feb. 9	5337	2	− .78	− .27	− .19
Sept. 1	5541	10	− .02	+ .25	+ .21
Sept. 23	5563	10	+ .18	+ .19	+ .21
Nov. 8	5609	10	+0.22	0.00	+0.15

$$\begin{array}{rrrcrl} 97\ x & -55.36\,y & -38.03\,z & = & +8.14'' & x = -0.075 \\ -55.36 & +51.49 & +12.19 & = & -4.16 & y = -0.100 \\ -38.03 & -4.16 & +45.51 & = & -10.18 & z = -0.259 \end{array}$$

VIII. *Radcliffe Meridian-Circle Observations of Polaris*, 1845–49. (From the annual volumes.) Reflected observations not used. Assumed $\theta = 0°.960$; $T'_0 = 239\,5700$.

1847	t	Obs.	O	C	C'
Feb. 15	5708	8	−0.85	−0.41	−0.20
Mar. 29	5750	8	− .22	− .30	− .21
Apr. 29	5781	11	− .16	− .12	− .16
May 29	5811	15	+ .58	+ .08	− .08
July 10	5853	7	− .04	+ .32	− .03
Sept. 9	5911	9	+ .31	+ .39	+ .21
Oct. 23	5958	9	− .05	+ .19	+ .19
Nov. 26	5992	7	+0.49	−0.04	+0.11

$$\begin{array}{rrrcrl} 8\ x & +1.02\,y & -0.35\,z & = & +1.13 & x = +0.128'' \\ +1.02 & +1.75 & +0.67 & = & -0.31 & y = -0.035 \\ -0.35 & +0.67 & +3.24 & = & -1.10 & z = -0.111 \end{array}$$

IX. *Washington Prime-Vertical Observations of α Lyrae*, 1845–50. (From the annual volumes of Observations, Lieuts. MAURY and HERNDON. (See *A.J.* XI. 109.) Assumed $\theta = 0°.923$; $T'_0 = 239\,6100$.

1847–8	t	Obs.	O	C	C'
Sept. 16	5921	21	+0.68	+0.22	+0.08
Oct. 7	5942	18	+ .10	+ .21	.00
Oct. 28	5963	31	+ .10	+ .17	− .08
Dec. 6	6002	22	+ .31	+ .06	− .18
Jan. 16	6043	23	− .53	− .08	− .22
Mar. 7	6094	17	− .10	− .20	− .13
May 3	6151	16	+ .12	− .19	+ .07
June 17	6196	23	− .16	− .06	+ .18
Aug. 7	6247	32	− .19	+ .11	+ .24
Sept. 4	6275	22	+0.12	+0.18	+0.16

$$\begin{array}{rrrcrl} 10\ x & -0.76\,y & -1.74\,z & = & -1.75'' & x = 0.216 \\ -0.76 & +4.80 & +0.35 & = & -0.19 & y = -0.058 \\ -1.74 & +0.35 & +5.19 & = & -0.75 & z = -0.213 \end{array}$$

X. *Greenwich Reflex Zenith-Tube Observations of γ Draconis*, 1852–59. (From MAIN's paper in the *Memoirs R.A.S.* XXIX.) Reduced to NYRÉN's aberration-constant. Assumed $\theta = 0°.900$; $T'_0 = 239\,8900$.

1855–6	t	Obs.	O	C	C'
Sept. 21	8848	51	−0.06	−0.18	−0.21
Nov. 1	8889	52	− .04	− .22	− .14
Dec. 27	8945	54	− .23	− .13	+ .04
Mar. 8	9017	55	− .09	+ .11	+ .21
Apr. 29	9069	53	+ .39	+ .21	+ .17
June 4	9105	55	+ .39	+ .21	+ .08
July 10	9141	55	.00	+ .14	− .04
Aug. 9	9171	55	+ .01	+ .05	− .14
Sept. 13	9206	53	−0.27	−0.07	−0.20

$$\begin{array}{rrrcrl} 9\ x & -1.40\,y & -0.86\,z & = & -2.12 & x = -0.281 \\ -1.40 & +4.30 & +0.03 & = & +0.61 & y = +0.\text{[illegible]}52 \\ -0.86 & +0.03 & +4.70 & = & -0.76 & z = -0.214 \end{array}$$

XI. GAMBEY *Mural Circle*, 1857–61. GAILLOT's deduction of latitude of the Paris Observatory from nadir-determinations; from which he inferred an annual instrumental variation. Personal differences of observers (*C.R.* LXXXVII (2), p. 685) not applied. Assumed $\theta = 0°.900$; $T' = 240\,0100$.

1858–9	t	Obs.	O	C	C'
May 15	9815	76	+0.17	+0.16	+0.21
June 20	9851	71	+ .06	+ .26	+ .20
July 19	9880	77	+ .23	+ .28	+ .13
Aug. 7	9899	69	+ .32	+ .26	+ .08
Sept. 3	9926	72	+ .34	+ .24	.02
Sept. 16	9939	75	+ .13	+ .15	− .06
Oct. 19	9968	69	+ .31	+ .04	− .16
Nov. 9	9993	78	− .11	− .07	− .20
Dec. 17	0031	81	− .20	− .21	.21
Feb. 9	0085	73	− .26	− .28	.12
Apr. 11	0146	85	− .15	[illegible]	[illegible]
May 15	0180	81	+0.17	+0.02	+0.17

$$\begin{array}{rrrcrcrcl} 12\,x & -0.36\,y & -2.73\,z & = & +0.48 & \qquad & x & = & -0.046'' \\ -0.36 & +5.95 & +0.48 & = & +0.50 & & y & = & +0.104 \\ -2.73 & +0.48 & +6.03 & = & -1.48 & & z & = & -0.264 \end{array}$$

XII. *Greenwich Reflex Zenith-Tube Observations of γ Draconis*, 1857–63. (From Downing's paper in *Mo. Not. R.A.S.* XLII.) These observations, extending from 1857–75, have here been separated into three parts. The present part overlaps series X in 1857–59, and is therefore not entirely independent of that. The remainder will be found in series XVIII and XXV. A change was made, in 1857, in the mounting of the mercury basin, which is supposed to have improved the character of the observations as to the accidental errors. No reduction for aberration (from the value 20″.400) was here made, as I have a definitive investigation in progress, in which the aberration-constant is included as an unknown, with the elements of the latitude-variation. Assumed $\theta = 0^\circ.900$; $T'_0 = 240\,0500$.

1859-60	t	Obs.	O	C	C′
			″	″	″
Dec. 23	0102	33½	—0.21	—0.02	—0.21
Feb. 13	0154	33	— .11	— .15	— .18
Mar. 9	0179	33	— .07	— .18	— .12
Apr. 18	0519	31	— .01	— .18	+ .01
May 11	0542	30	— .40	— .14	+ .08
June 2	0561	34	+ .05	— .09	+ .16
June 22	0581	29	— .15	— .03	+ .20
July 12	0604	33	— .10	+ .03	+ .21
Aug. 1	0624	30	+ .05	+ .08	+ .21
Aug. 17	0640	34	+ .26	+ .12	+ .20
Sept. 9	0663	29	+ .13	+ .17	+ .16
Sept. 29	0683	34	+ .22	+ .19	+ .11
Oct. 22	0706	34	+ .30	+ .19	+ .04
Nov. 14	0729	32	+ .19	+ .16	— .04
Dec. 15	0760	32	+0.04	+0.10	—0.15

$$\begin{array}{rrrcrcrcl} 15\,x & +2.91\,y & -1.05\,z & = & -1.01'' & \qquad & x & = & -0.084'' \\ +2.91 & +7.10 & -0.02 & = & -0.13 & & y & = & +0.015 \\ -1.05 & -0.02 & +7.61 & = & -1.38 & & z & = & -0.193 \end{array}$$

XIII. Moesta's *Meridian-Circle Observations of β Centauri, Santiago*, 1860–64. (See remarks on series VI.) Assumed $\theta = 0^\circ.843$; $T'_0 = 240\,0973$.

1861-2	t	Obs.	O	C	C′
			″	″	″
Mar. 25	0860	34	—0.02	+0.01	+0.08
May 23	0919	28	— .08	+ .11	+ .21
July 18	0975	31	+ .40	+ .17	+ .18
Dec. 1	1111	28	— .25	— .10	— .20
Jan. 12	1153	29	— .07	— .16	— .21
Feb. 12	1184	31	— .29	— .17	— .16
Mar. 20	1220	27	+0.08	—0.13	—0.04

$$\begin{array}{rrrcrcrcl} 7\,x & -0.74\,y & -1.59\,z & = & -0.02'' & \qquad & x & = & +0.032'' \\ -0.74 & +2.74 & -0.82 & = & -0.24 & & y & = & -0.028 \\ -1.59 & -0.82 & +4.26 & = & +0.69 & & z & = & +0.169 \end{array}$$

XIV. *Washington Prime-Vertical Observations of α Lyrae*, 1862–67. (See *A.J.* XI, 68, 69.) The solution here given is based on column *A*, p. 69. Assumed $\theta = 0^\circ.843$; $T'_0 = 240\,2217$.

1864-6	t	Obs.	O	C	C′
			″	″	″
Nov. 28	2201	30	—0.31	—0.16	+0.11
Dec. 30	2236	31	— .09	— .16	.00
Jan. 31	2268	31	— .05	— .12	— .10
Feb. 25	2293	32	— .02	— .08	— .16
Apr. 2	2329	34	— .05	+ .01	— .21
May 11	2368	28	+ .11	+ .09	— .19
June 2	2390	26	.00	+ .13	— .15
July 15	2433	30	+ .09	+ .16	— .02
Aug. 9	2458	26	+ .21	+ .15	+ .07
Sept. 5	2485	28	+ .30	+ .12	+ .14
Sept. 30	2510	29	+ .08	+ .07	+ .19
Oct. 22	2532	29	— .06	+ .02	+ .21
Nov. 22	2563	27	— .26	— .05	+ .20
Dec. 18	2589	20	— .02	— .11	+ .16
Jan. 6	2608	29	—0.03	—0.13	+0.12

$$\begin{array}{rrrcrcrcl} 15\,x & -1.29\,y & -0.11\,z & = & +0.37'' & \qquad & x & = & +0.028'' \\ -1.29 & +7.50 & -0.01 & = & +0.14 & & y & = & +0.063 \\ -0.11 & -0.01 & +7.51 & = & -1.12 & & z & = & -0.149 \end{array}$$

XV. Gyldén's *Vertical Circle Observations of 15 stars south of Pulkowa zenith*, 1863–67. (See *A.J.* XI. 67.) Assumed $\theta = 0^\circ.843$; $T'_0 = 240\,2374$.

1865-6	t	Obs.	O	C	C′
			″	″	″
July 3	2421	17	+0.02	—0.08	—0.18
Aug. 5	2454	23	+ .02	+ .02	— .21
Sept. 26	2506	33	+ .13	+ .17	— .16
Nov. 19	2560	21	+ .18	+ .22	.00
Dec. 27	2598	29	+ .23	+ .17	+ .12
Mar. 1	2665	7	+ .02	— .02	+ .22
May 2	2729	36	— .23	— .19	+ .11
July 4	2787	53	—0.26	—0.21	—0.08

$$\begin{array}{rrrcrcrcl} 8\,x & +0.75\,y & -0.06\,z & = & +0.19'' & \qquad & x & = & +0.012'' \\ +0.75 & +3.91 & +0.06 & = & +0.42 & & y & = & +0.107 \\ -0.06 & +0.06 & +4.07 & = & -0.79 & & z & = & -0.196 \end{array}$$

XVI. *Leyden Meridian-Circle Observations of Polaris*, 1864–68. (See *A.J.* XI. 75, 76.) Assumed $\theta = 0^\circ.843$; $T'_0 = 240\,2343$.

1865-6	t	Obs.	O	C	C′
			″	″	″
June 19	2407	50	—0.11	—0.09	—0.20
Aug. 2	2451	108	+ .02	— .03	— .21
Sept. 22	2502	96	+ .05	+ .05	— .09
Nov. 15	2556	78	+ .08	+ .10	+ .08
Jan. 2	2604	190	+ .08	+ .10	+ .19
Mar. 15	2676	50	+ .01	+ .01	+ .17
May 25	2717	82	— .07	— .09	— .04
July 3	2786	166	—0.14	—0.11	—0.16

$$\begin{array}{rrrcrcrcl} 8\,x & +0.81\,y & +0.22\,z & = & +0.03'' & \qquad & x & = & +0.010'' \\ +0.81 & +3.71 & +0.18 & = & -0.13 & & y & = & -0.032 \\ +0.22 & +0.18 & +4.30 & = & -0.44 & & z & = & -0.102 \end{array}$$

XVII. Gyldén's *Vertical Circle Observations of Polaris*, 1863–70. (See *A.J.* XI, 66, 67.) Assumed $\theta = 0^\circ.843$; $T'_0 = 240\,2374$.

1865–67	t	Obs.	O	C′	C
July 9	2427	30	—0.16	—0.21	—0.20
Aug. 14	2463	26	— .14	— .14	— .22
Oct. 3	2513	26	— .02	.00	— .11
Nov. 21	2562	26	+ .05	+ .15	.00
Dec. 26	2597	23	+ .25	+ .21	+ .12
Mar. 8	2669	26	+ .25	+ .16	+ .24
May 10	2732	23	— .11	— .02	+ .11
May 31	2753	30	— .13	— .09	+ .04
July 31	2814	26	—0.17	—0.21	—0.16

$$\begin{array}{rrrcrl} 9\;x & +0.51\,y & +0.49\,z & = & -0.27'' & x = -0.014'' \\ +0.54 & +4.42 & -0.27 & = & -0.37 & y = -0.094 \\ +0.49 & -0.27 & +4.57 & = & -0.87 & z = -0.194 \end{array}$$

XVIII. *Greenwich Reflex Zenith-Tube Observations of γ Draconis*, 1861–70. (See series XII.) Assumed $\theta = 0°.878$; $T'_0 = 2402900$.

1866–7	t	Obs.	O	C′	C
July 9	2792	26	—0.14	—0.27	—0.18
Aug. 3	2817	25	— .52	— .30	— .21
Sept. 2	2847	24½	— .02	— .27	— .21
Oct. 2	2877	20½	— .21	— .19	— .17
Oct. 29	2904	23	— .14	— .08	— .09
Nov. 25	2931	20	+ .20	+ .04	— .01
Jan. 18	2985	24	+ .02	+ .25	+ .16
Mar. 22	3048	24½	— .05	+ .28	+ .21
Apr. 22	3079	27	+ .82	+ .20	+ .17
May 19	3106	25	+ .22	+ .10	+ .11
June 10	3128	25	— .05	.00	+ .04
July 1	3149	25	— .43	— .10	— .04
July 30	3178	26	—0.25	—0.21	—0.13

$$\begin{array}{rrrcrl} 13\;x & -2.29\,y & -0.73\,z & = & -3.41'' & x = -0.219'' \\ -2.29 & +5.75 & -0.08 & = & +2.11 & y = +0.278 \\ -0.73 & -0.08 & +7.24 & = & -0.58 & z = -0.099 \end{array}$$

XIX. *Melbourne Transit-Circle Observations of* 36 *of* GOULD'S *Southern Standard Circumpolars*, 1863–67.5. (From annual volumes.) See *A.J.* XI, 75, 76 for general description of treatment, and data for this series. The whole series from 1863–80 has been separated into four parts; the other three parts are given in series XXI, XXIV and XXVIII. Assumed $\theta = 0°.843$; $T'_0 = 2402937$.

1866–7	t	Obs.	O	C′	C
Jan. 28	2630	66	—0.06	—0.01	—0.18
Apr. 1	2693	51	+ .10	+ .08	.00
May 29	2751	47	+ .20	+ .11	+ .17
Aug. 14	2828	125	— .04	+ .07	+ .19
Oct. 5	2880	118	+ .03	— .03	+ .06
Dec. 1	2940	83	— .09	— .13	— .13
Jan. 25	2992	104	—0.17	—0.13	—0.22

$$\begin{array}{rrrcrl} 7\;x & +0.05\,y & +0.31\,z & = & +0.88'' & x = +0.132'' \\ +0.05 & +3.38 & -0.11 & = & -0.20 & y = -0.066 \\ +0.31 & -0.14 & +3.62 & = & -0.40 & z = -0.125 \end{array}$$

XX. *Washington Transit-Circle Observations of Polaris*, 1866–70.6. (From annual volumes. See *A.J.* XI, 108.) The series from 1866–85 has been separated into five parts; the other four parts are given in series XXVI, XXX, XXXII and XXXIX. The phenomenon of the latitude-variation emerges with great clearness from these observations of *Polaris*, as well as from those of the other three close polars elsewhere given in this investigation. Two of the nine groups give discordant results; but in one of these the contradiction is due to *λ Ursae min.* alone, the other stars being harmonious. I feel sure that, nothwithstanding the considerable accidental errors and the numerous misprints, the results of this instrument do not deserve much of the discredit which has heretofore attached to them, so far as systematic instrumental errors are concerned. I hope on some future occasion to publish a more thorough investigation of the latitude-variation based on these observations. Assumed $\theta = 0°.843$; $T'_0 = 2403528$.

1868–9	t	Obs.	O	C′	C
Jan. 14	3346	57½	+0.23	+0.24	+0.21
Feb. 14	3377	10½	+ .25	+ .09	+ .21
Mar. 15	3407	11½	— .06	— .08	+ .16
Apr. 15	3438	21	— .48	— .23	+ .08
May 16	3469	37½	— .45	— .34	— .04
June 16	3500	11	— .26	— .38	— .14
July 15	3529	19½	— .39	— .35	— .20
Aug. 15	3560	45	— .07	— .24	— .22
Sept. 15	3591	53	+ .20	— .09	— .20
Oct. 15	3621	53½	— .12	+ .08	— .13
Nov 15	3652	61	+ .06	+ .23	— .02
Dec. 15	3682	65½	+ .11	+ .34	+ .06
Jan. 14	3712	59	+ .63	+ .38	+ .14
Feb. 14	3743	59	+0.36	+0.34	+0.20

$$\begin{array}{rrrcrl} 11\;x & +0.03\,y & -0.01\,z & = & -6.29'' & x = -0.450 \\ +0.03 & +6.98 & -0.01 & = & +1.06 & y = +0.153 \\ -0.01 & -0.01 & +7.01 & = & -2.45 & z = -0.350 \end{array}$$

XXI. *Melbourne Transit-Circle Observations of* 36 *of* GOULD'S *Southern Standard Circumpolars*, 1867.5–1871.5. (See series XIX.) Assumed $\theta = 0°.843$; $T'_0 = 2403701$.

1868–9	t	Obs.	O	C′	C
Oct. 30	3636	98	+0.12	[illegible]	[illegible]
Dec. 29	3696	118	+ .02	[illegible]	.07
Feb. 26	3755	96	— .06	[illegible]	— .12
Apr. 30	3818	106	+ .24	[illegible]	— .22
June 30	3879	177	— .04	[illegible]	— [illegible]
Aug. 30	3940	175	— .11	[illegible]	[illegible]
Nov. 2	4004	157	—0.12	[illegible]	[illegible]

$$\begin{array}{rrrcrl} 7\;x & -0.08\,y & -0.00\,z & = & [illegible] & [illegible] \\ -0.08 & +3.54 & +0.12 & = & [illegible] & [illegible] \\ 0.00 & +0.02 & +3.46 & = & [illegible] & [illegible] \end{array}$$

XXII. *Washington Transit-Circle Observations of* [illegible] *λ Ursae minoris*, and 51 *H. Cephei*, 1866–72. [illegible] the corresponding data for *Polaris*, in series XX. [illegible] rated into three parts; the other two parts are given in series XXVII and XXXV. Assumed [illegible] 2403955.

18[illegible]	t	Obs.	O	C	C′
Sept. 2	3943	46½	−0.31	−0.34	−0.20
Oct. 31	4002	17	− .62	− .31	− .20
Dec. 9	4041	59½	+ .17	− .18	− .12
Feb. 19	4113	63	+ .11	+ .16	+ .44
Apr. 11	4167	49	+ .26	+ .33	+ .21
June 23	4237	86	+ .21	+ .25	+ .11
Aug. 22	4297	70	+0.11	−0.02	−0.01

$$\begin{array}{rrrcr|rcl} 7\,x & +0.36\,y & +0.15\,z & = & +0.53'' & x & = & +0.087'' \\ +0.36 & +3.50 & +0.23 & = & -0.34 & y & = & -0.084 \\ +0.15 & +0.23 & +3.50 & = & -1.16 & z & = & -0.330 \end{array}$$

XXIII. Nyrén's *Vertical Circle Observations of Polaris*, 1871–75. (See *A.J.* XI, 67, 68.) Assumed $\theta = 0^\circ.843$; $T'_0 = 2404936$.

1872–3	t	Obs.	O	C	C′
Sept. 3	5040	23	−0.01″	−0.07″	+0.03″
Nov. 6	5101	30	.00	+ .07	+ .20
Jan. 15	5171	29	+ .19	+ .15	+ .18
Feb. 16	5206	27	+ .11	+ .11	+ .11
Mar. 24	5242	33	+ .09	+ .09	− .02
May 2	5281	10	.00	+ .01	− .12
June 17	5327	29	− .09	− .08	− .21
Aug. 4	5375	27	−0.12	−0.14	−0.19

$$\begin{array}{rrrcr|rcl} 8\,x & -1.86\,y & -0.46\,z & = & +0.17'' & x & = & -0.001'' \\ -1.86 & +4.33 & -0.07 & = & -0.26 & y & = & -0.062 \\ -0.46 & -0.07 & +3.67 & = & -0.48 & z & = & -0.132 \end{array}$$

XXIV. *Melbourne Transit-Circle Observations of 36 of* Gould's *Southern Standard Circumpolars*, 1871.5–75.5. (See series XIX.) Assumed $\theta = 0^\circ.843$; $T'_0 = 2405072$.

1872–3	t	Obs.	O	C	C′
Nov. 29	5127	95	−0.18″	−0.19″	−0.12″
Jan. 29	5188	57	+ .15	− .07	+ .07
Mar. 31	5249	91	+ .63	+ .11	+ .20
May 31	5310	115	+ .24	+ .20	+ .18
July 31	5371	98	+ .07	+ .15	+ .01
Sept. 30	5432	78	+ .04	− .02	− .15
Nov. 30	5493	114	−0.03	−0.17	−0.21

$$\begin{array}{rrrcr|rcl} 7\,x & +0.00\,y & +0.00\,z & = & -0.85 & x & = & -0.121'' \\ 0.00 & +3.50 & 0.00 & = & -0.34 & y & = & -0.097 \\ 0.00 & +0.00 & +3.50 & = & -0.63 & z & = & -0.180 \end{array}$$

XXV. *Greenwich Reflex Zenith-Tube Observations of γ Draconis*, 1871–75. (See series XII.) Assumed $\theta = 0^\circ.857$; $T'_0 = 2405100$.

1872–3	t	Obs.	O	C	C′
May 12	4926	27	+0.04″	−0.02″	−0.19″
June 28	4973	26½	− .26	− .05	− .08
Aug. 25	5031	29	.00	− .10	+ .11
Oct. 5	5072	25	.00	− .09	+ .20
Nov. 30	5128	28	− .06	− .03	+ .20
Jan. 27	5186	24	.00	+ .06	+ .06
Mar. 14	5232	22	− .02	+ .10	− .08
Apr. 25	5271	27	+ .26	+ .10	− .19
May 29	5308	29½	+0.10	+0.07	−0.22

$$\begin{array}{rrrcr|rcl} 9\,x & +0.10\,y & -0.82\,z & = & -2.60'' & x & = & -0.295'' \\ +0.10 & +4.27 & -0.25 & = & +0.30 & y & = & +0.074 \\ -0.82 & -0.25 & +4.75 & = & -0.07 & z & = & -0.062 \end{array}$$

XXVI. *Washington Transit-Circle Observations of Polaris*, 1871.6–75.7. (See series XX.) Assumed $\theta = 0^\circ.843$; $T'_0 = 2405236$.

1872–3	t	Obs.	O	C	C′
Oct. 15	5082	25	+0.55″	−0.02″	+0.10″
Nov. 14	5112	37	+ .11	− .08	.00
Dec. 14	5142	16	+ .27	− .12	− .08
Jan. 13	5172	29	− .56	− .14	− .16
Feb. 12	5202	22	− .39	− .13	− .22
Mar. 15	5233	26	− .34	− .10	− .21
Apr. 15	5264	23	− .29	− .05	− .17
May 15	5294	33	− .08	+ .01	− .09
June 15	5325	26	+ .97	+ .07	+ .01
July 15	5355	31	+ .17	+ .12	+ .10
Aug. 15	5386	30	− .15	+ .14	+ .17
Sept. 15	5417	32	− .37	+ .13	+ .21
Oct. 15	5447	28	− .02	+ .10	+ .21
Nov. 15	5478	26	+0.14	+0.05	+0.16

$$\begin{array}{rrrcr|rcl} 14\,x & -0.05\,y & +0.02\,z & = & -4.33'' & x & = & -0.309'' \\ -0.05 & +7.03 & -0.01 & = & +0.75 & y & = & +0.104 \\ +0.02 & -0.01 & +6.97 & = & -0.68 & z & = & -0.097 \end{array}$$

(*Continued in No. 273.*)

ON THE LIGHT-VARIATIONS OF *Y OPHIUCHI* (Ch. 6404),

By EDWIN F. SAWYER.

The variability of this star was announced in No. 210 of this Journal. From a preliminary reduction of my then available observations, I found a period of about $17^d.14$. From a final discussion of all my observations to the present time, I find a slightly shorter period, and have adopted as the best attainable elements, 1882 September $4^d.428$ Gr. $+ 17^d.125641\,E$ = 1882 Sept. $4^d\,10^h\,16^m$ Gr. $+ (17^d\,3^h\,1^m.0)\,E$ for the epoch of maximum. The minimum occurs earlier by $6^d.250$. The observed times of the maxima and minima, given below, were derived as heretofore by applying, to the time of each observation of the variable, the correction indicated by the comparison of its observed light with the mean light-curve hereafter given. Values of $L. > 8.5$ were employed for deducing the maxima, the others

for the minima. In forming each epoch, the number of observations gives the weight in the third column. The column O — C is a comparison with the preceding elements.

E	Observed Maxima. Boston M.T.	Wt.	O — C	E	Observed Minima. Boston M.T.	Wt.	O — C
			d				d
0	82 Sept. 5.43	1	+0.90	87	86 Sept. 30.41	1	+3.50
86	86 Sept. 15.12	1	— .91	88	Oct. 15.16	1	+1.13
129	88 Sept. 21.48	1	+0.08	125	88 July 6.42	1	—2.27
130	Oct. 9.76	1	+1.20	130	Sept. 2.68	2	+0.37
147	89 July 27.21	3	+0.51	146	89 June 3.62	5	+ .30
148	Aug. 14.01	1	+1.19	147	20.74	7	+ .29
149	29.11	3	—0.84	149	Aug. 23.12	7	— .58
150	Sept. 16.39	2	+ .31	151	Sept. 26.87	1	— .08
152	Oct. 20.28	5	— .05	152	Oct. 13.92	4	— .16
164	90 May 13.65	1	— .18	165	90 May 21.61	3	— .10
166	June 17.09	4	.00	166	June 10.79	7	— .05
168	July 21.91	2	+ .57	168	July 15.37	4	+ .28
169	Aug. 8.13	1	+ .67	169	Aug. 1.07	4	— .11
172	Sept. 27.87	3	+ .03	170	18.16	2	— .18
173	Oct. 11.93	3	— .03	171	Sept. 3.85	1	— .61
174	Nov. 1.88	2	+ .79	172	22.52	2	+ .93
187	91 June 11.77	5	+ .05	173	Oct. 8.33	3	— .39
188	28.16	3	— .69	187	91 June 5.37	4	— .10
189	July 16.42	1	+ .44	188	23.18	3	+ .88
190	Aug. 2.43	3	+ .33	189	July 9.72	3	— .01
191	20.12	3	+ .89	190	26.84	1	— .01
192	Sept. 5.09	3	— .26	191	Aug. 12.69	3	— .29
193	22.11	3	— .37	192	30.24	2	+ .14
194	Oct. 9.33	2	— .27	193	Sept. 15.67	1	— .56
195	25.80	2	—0.93	194	Oct. 3.96	3	+ .61
				195	20.33	5	—0.15

The comparison-stars and the adopted light-scale are given below; the positions being for 1875.0.

Brighton, Mass., 1892 *July* 4.

a	183 (*U.A.*) *Oph.*	17 50 11	[illegible]	5.8	[illegible]	[illegible]
b	187 " "	17 52 58	—4 18.4	[illegible]	[illegible]	[illegible]
c	167 " "	17 37 2	—7 1.2	[illegible]	[illegible]	[illegible]
d	194 " "	17 56 6	—5 21.3	[illegible]	[illegible]	[illegible]
e	178 " "	17 45 58	—5 [illegible]	[illegible]	[illegible]	2.7
f	S.DM. 5 1523	17 46 34	[illegible]	—	7.20	[illegible]

All the observations were used, and [illegible] employed in the formation of the mean [illegible]. The characteristics of the light-fluctuations [illegible] form and not very rapid increase; a decrease [illegible] and somewhat rapid, followed by a slow [illegible] regular course. The duration of increase is 6.25 days, and that of decrease is 10.88 days. The maximum phase occupies about one day. The readings of the light-curve give the following

Light-Table.

Time from Max.	Light	Time from Max.	Light	Time from Max.	Light
d		d			
—6.25	3.7	0.00	12.0	+6.00	7.[illegible]
6.00	3.7	+0.50	12.0	6.50	6.[illegible]
5.50	3.7	1.00	11.9	7.00	[illegible]
5.00	4.0	1.50	11.7	7.50	5.[illegible]
4.50	4.4	2.00	11.3	8.00	[illegible]
4.00	5.0	2.50	10.6	8.50	4.7
3.50	5.6	3.00	9.7	9.00	4.3
3.00	6.5	3.50	9.0	9.50	4.1
2.50	7.3	4.00	8.5	10.00	3.8
2.00	8.0	4.50	8.1	10.50	3.7
1.50	9.2	5.00	7.7	11.00	3.7
1.00	11.5	+5.50	7.4	+11.50	3.7
—0.50	12.0				

The range of variation is from 6ᵐ.25 to 6ᵐ.95. The [illegible] curve at minimum appears somewhat less [illegible] determined, this phase occupying about a day [illegible].

The star appears slightly colored, or about 2 [illegible] Chandler's scale.

OBSERVATIONS OF VARIABLE STARS, 1891–92.

BY PAUL S. YENDELL

1953 *T* (*Nova*) *Aurigæ*.

Since the observations published on p. 143 of Vol. XI of this Journal, I have obtained eight more observations of this star, as follows:

	m	w	
1892 Mar. 13.302	7.9	4	Moon full
14.302	8.1	4	
15.316	8.7	4	
16.319	8.8	4	
19.319	9.5	4	
21.306	10.0	3	eye estimate
24.326	<10.0		" "
25.340	10.5	3	

2100 *U Orionis*.

From 1891 Dec. 3 to 1892 Feb. 18, I observed *U Orionis* twenty-five times. Its magnitude when first seen was estimated at 11ᵐ [illegible]; its increase was steady [illegible] observations indicate a maximum of [illegible] 1892 [illegible]. Its magnitude at the last observation was 7 [illegible].

2275 *T M*[illegible]

A series of fifty-nine observations, [illegible] 1892 April 26, indicating a maximum at [illegible] follows:

Maxima	w	Minima	
1891 Sept. 11.87	2	1891 Oct. 2[illegible]	
Nov. 2[illegible].1		Dec. [illegible]	
28.6	1	1892 Jan. [illegible]	
1892 Jan. [illegible].25	1	[illegible]	1
20.[illegible]	1	M[illegible]	1
Feb. 17.6	1	A[illegible]	
Mar. 14.5	1		
April 13.4	1		

2478 *R Lyncis.*

Eleven observations of *R Lyncis*, from 1892 Mar. 19 to May 27, indicate a maximum of $7^{\rm M}.5$, 1892 May 11.

2625 *V Monocerotis.*

Six observations, from 1892 Mar. 15 to April 21, show a maximum on 1892 Mar. 19.5.

3185 *T Hydrae.*

Five observations of *T Hydrae*, from 1892 Mar. 15 to April 20, show a maximum of $8^{\rm M}.0$, 1892 Mar. 20.

3976 *U Hydrae.*

Seventeen observations show this star to have been near a maximum from 1892 Mar. 19 to April 30, the fluctuations during this entire interval being only from $5^{\rm M}.1$ to $5^{\rm M}.6$; the observations do not indicate a distinct maximum.

4805 *W Virginis.*

My observations of this star for the seasons of 1891 and 1892 indicate maxima and minima, as follows:

Maxima	w	Minima
1891 April 2.15	2	1891 Mar. 26.52
May 8.94	3	April 11.15
25.89	1	June 3.21
June 11.00	2	1892 Mar. 25.0
28.78	1	April 26.2
1892 Mar. 31.7	4	May 31.7
April 16.7	1	
May 22.3	3	
June 13.4	1	

The observations for 1891 were reduced by the use of a mean light-curve formed from all my observations, 110 in number, from 1889 till the close of the present season. The normal lights indicate quite distinctly a secondary maximum about four days after the principal one, somewhat resembling the curve of SCHMIDT, published in the *Astronomische Nachrichten*, 80, 142. This inflection was neglected in drawing the curve which was actually used, as the whole rests on too few observations to be definitive in character; the maximum of June 13.4, however, which was quite well-determined, shows a residual of $+1^{\rm d}.74$.

4847 *S Virginis.*

This star has been observed twelve times, from 1892 Mar. 24 to June 11. A maximum of $6^{\rm M}.7$ is indicated on April 14.

5501 *S Serpentis.*

Thirteen observations of this star, from 1892 April 20 to June 15, indicate a maximum on May 11.5, at a magnitude of $7^{\rm M}.5$.

6733 *R Scuti.*

Fifty-four observations were obtained, from 1891 May 27 to Nov. 4. When first observed, the star was evidently very near a maximum, its magnitude being by estimation $4^{\rm M}.8$; it fell off, at first quickly, and afterward more slowly, and a minimum of $7^{\rm M}.2$ was indicated on Aug. 20. On Oct. 1 the star passed a bright maximum of $4^{\rm M}.4$, and when last observed had fallen to $6^{\rm M}.2$.

Dorchester, Mass., 1892 *July* 23.

NEW CATALOGUE OF VARIABLE STARS.

It is hoped soon to issue a second edition of the Catalogue of Variable Stars. The accumulation of data since the publication of the first edition, and the supplement thereto (*A.J.* nos. 179–80 and 216), has been very considerable, and their investigation, and the incorporation of the resulting changes, improvements and additions, into the new edition, will consume much time and labor; so that it will probably not be practicable to issue it until some time during the coming winter. Since it is a matter of common interest to those who are occupied with the subject, that such a publication shall be brought as thoroughly up to date as possible, this early notice is given in order that those who have unpublished observations, or who propose to make observations this season, may have opportunity, if they feel disposed, to make the results known by publication before the end of the current year, or immediately after. For all observations pertaining to stars whose variability has been announced, but not yet independently or sufficiently confirmed for insertion among the known variables, the need is especially urgent; although those relating to stars of known variability whose periods and other characteristics are yet unknown, or imperfectly so, are almost equally important.

If it seems to be sufficiently desired by observers, a preliminary working-list of such objects will be printed, in season for much valuable work to be done upon them and published, and the serviceableness of the new Catalogue thereby much enhanced.

S. C. CHANDLER.

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ON THE VARIATION OF LATITUDE. VI.

BY S. C. CHANDLER.

Continued from page 62.

XXVII. *Washington Transit-Circle Observations of δ and λ Ursae minoris, and 51 H Cephei*, 1873.0–80.0. (See series XXII.) Assumed $\theta = 0''.813$; $T'_0 = 2406517$.

1876–77	t	Obs.	O	C	C'
Sept. 1	6499	51	−0.04	−0.13	−0.09
Oct. 26	6554	78	− .05	− .08	− .21
Jan. 1	6621	95	− .04	+ .01	− .17
Feb. 25	6676	99	+ .11	+ .12	− .02
May 1	6741	95	+ .18	+ .11	+ .17
July 2	6803	91	+ .01	+ .02	+ .21
Aug. 30	6862	62	−0.20	−0.09	+0.11

$7\,x + 0.01\,y + 0.06\,z = +0.11 \qquad x = +0.017$
$+0.01 \quad +3.52 \quad -0.03 \quad = +0.17 \qquad y = +0.047$
$+0.06 \quad -0.03 \quad +3.48 \quad = -0.41 \qquad z = -0.118$

XXVIII. *Melbourne Transit-Circle Observations of* 36 *of* GOULD's *Southern Standard Circumpolars*, 1875.5–80.0. (See series XIX.) Assumed $\theta = 0''.813$; $T'_0 = 2406780$.

1877–78	t	Obs.	O	C	C'
Apr. 30	6740	77	−0.17	−0.12	−0.21
June 30	6801	89	+ .03	− .08	− .11
Aug. 28	6860	65	− .01	− .01	+ .02
Nov. 2	6926	66	− .03	+ .10	+ .12
Jan. 11	6996	77	+ .23	+ .10	+ .19
Mar. 1	7045	87	+ .05	+ .01	+ .07
May 1	7106	66	−0.14	−0.06	+0.12

$7\,x - 0.21\,y - 0.02\,z = -0.95 \qquad x = -0.134$
$-0.21 \quad +3.42 \quad +0.18 \quad = +0.20 \qquad y = +0.056$
$-0.02 \quad +0.18 \quad +3.58 \quad = -0.37 \qquad z = -0.107$

XXIX. *Cordoba Meridian-Circle Observations of Southern Standard Circumpolars*, 1872.5–81.0. (From GOULD's discussion, *A.J.* XI, 129–131, 137–140.) The residuals used are those of the last column of the table on p. 138, i.e. Assumed $\theta = 0''.813$; $T'_0 = 2406532$.

1875–77	t	Obs.	O	C	C'
Dec. 15	6238	683	+0.01	+0.06	+0.17
Jan. 15	6269	668	+ .13	+ .11	+ .21
Feb. 15	6300	599	− .03	+ .13	+ .21
Mar. 15	6329	761	+0.17	+0.12	+0.17
Apr. 15	6360	717	+0.18	+0.10	+0.[illegible]
May 15	6390	615	+ .03	+ .05	[illegible]
June 15	6421	736	+ .10	− .01	− [illegible]
July 15	6451	674	− .11	− .06	− .17
Aug. 15	6482	651	− .22	− .11	− .21
Sept. 15	6513	551	− .12	− .13	− .21
Oct. 15	6543	636	− .18	− .12	− .18
Nov. 15	6571	480	+ .04	− .09	− [illegible]
Dec. 15	6604	572	.00	− .05	.00
Jan. 15	6635	639	+0.01	+0.01	+0.[illegible]

$11\,x + 0.01\,y - 0.03\,z = +0.01 \qquad x = 0.000$
$+0.01 \quad +7.00 \quad +0.03 \quad = +0.11 \qquad y = +0.016$
$-0.03 \quad +0.03 \quad +7.02 \quad = -0.89 \qquad z = -0.127$

XXX. *Washington Transit-Circle Observations of Polaris*, 1875.8–79.0. (See series XX.) Assumed $\theta = 0''.813$; $T'_0 = 2406911$.

1877–78	t	Obs.	O	C	C'
June 16	6787	26	+0.48	+0.28	+0.[illegible]
July 15	6816	29	+ .26	+ .15	− [illegible]
Aug. 15	6847	15	− .17	− .03	− [illegible]
Sept. 15	6878	17	− .32	− .20	− [illegible]
Oct. 15	6908	22	− .34	− .32	− .22
Nov. 16	6940	25	− .71	− .59	− [illegible]
Dec. 16	6970	27	+ .14	− .37	[illegible]
Jan. 16	7001	18	− .31	− .28	− [illegible]
Feb. 15	7031	34	− .19	− .14	+ [illegible]
Mar. 16	7060	32	− .20	+ .02	+ .14
Apr. 17	7092	29	+ .03	+ .20	+ .20
May 16	7121	21	+ .66	+ .32	+ .22
June 16	7152	25	+ .45	+ .39	+ .29
July 16	7182	31	+0.28	+0.37	+0.11

$11\,x + 0.06\,y - 0.03\,z = -0.32 \qquad x = [illegible]$
$+0.06 \quad +7.03 \quad -0.01 \quad = -0.28 \qquad y = [illegible]$
$-0.03 \quad -0.01 \quad +7.82 \quad = -2.[illegible]8 \qquad z = [illegible]$

XXXI. *Pulkowa Prime-Vertical Observations of* [illegible] 24 *zenith stars*, 1879.9–82.1. (From pp. 37, 58 of NYRÉN's [illegible] on the Aberration, Acad. St. Petersbourg, XXXI. [illegible]) Assumed $\theta = 0''.813$; $T'_0 = 2407025$.

1880-81	t	Obs.	O	C	C′
			″		
July 11	7908	60	0.00	−0.05	−0.21
Aug. 16	7944	63	− .07	− .07	− .16
Sept. 23	7982	61½	− .07	− .07	− .07
Nov. 15	8035	52	− .01	− .01	+ .10
Jan. 22	8103	44	− .01	+ .03	+ .21
Mar. 9	8150	78	+ .17	+ .06	+ .18
Apr. 24	8196	77	+ .03	+ .07	+ .08
May 19	8220	62	+ .02	+ .06	.00
June 30	8262	58	+0.01	+0.02	−0.12

$$\begin{array}{rrrcrl} 9\,x & -0.55\,y & -0.09\,z & = & -0''.05 & x = -0''.008 \\ -0.55 & +1.34 & +0.82 & = & -0.20 & y = -0.037 \\ -0.09 & +0.82 & +1.66 & = & -0.29 & z = -0.056 \end{array}$$

XXXII. *Washington Transit-Circle Observations of Polaris*, 1879.4–83.0. (See series XX.) Assumed $\theta = 0^\circ.843$; $T'_0 = 2408225$.

1880-82	t	Obs.	O	C	C′
			″	″	″
Dec. 15	8065	30	+0.16	+0.08	+0.08
Jan. 13	8094	12	− .30	+ .02	− .01
Feb. 11	8126	24	− .17	− .06	− .11
Mar. 15	8155	21	− .14	− .12	− .18
Apr. 15	8186	23	+ .23	− .16	− .21
May 15	8216	17	+ .34	− .17	− .21
June 16	8248	16	− .39	− .11	− .16
July 16	8278	36	− .63	− .09	− .08
Aug. 15	8308	13	− .24	− .01	+ .01
Sept. 15	8339	39	+ .15	+ .06	+ .10
Oct. 15	8369	28	+ .80	+ .12	+ .18
Nov. 15	8400	30	+ .06	+ .16	+ .21
Dec. 16	8431	32	+ .04	+ .17	+ .21
Jan. 16	8462	23	+0.13	+0.14	+0.17

$$\begin{array}{rrrcrl} 14\,x & -0.01\,y & 0.00\,z & = & -11''.58 & x = -0''.827 \\ -0.01 & +7.03 & +0.03 & = & +\ 0.33 & y = +0.043 \\ 0.00 & +0.03 & +6.97 & = & -\ 1.11 & z = -0.160 \end{array}$$

XXXIII. *Willet's Point Zenith-Telescope Observations*, 1880.8–85.6. The data for this series were kindly furnished by Gen. H. L. ABBOT, from the original records. The observations were made under his direction to determine the latitude of the New Engineer Observatory, and are especially interesting; first, because both the instrument and method, now so generally adopted, were essentially the invention (in 1834) of Capt TALCOTT of this Corps, and are known by his name, although that of HORREBOW is sometimes appended thereto, with little reason or justice; secondly, because Gen ABBOT himself pointed out, about eight years since, the fact that they indicate a latitude-variation. (See General Orders U.S. Engineers.) Assumed $\theta = 0^\circ.843$; $T'_0 = 2408655$.

1882-83	t	Obs.	O	C	C′
			″	″	″
Nov. 6	8756	235	+0.07	+0.10	+0.04
Nov. 27	8777	235	+ .12	+ .17	+ .10
Dec. 27	8807	356	+ .17	+ .25	+ .17
Feb. 21	8863	243	+ .59	+ .25	+ .21
Mar. 8	8878	288	+ .25	+ .22	+ .16
Mar. 24	8894	257	−0.07	+0.18	+0.11
Apr. 28	8929	245	+0.22	+0.06	+0.05
June 8	8970	253	− .29	− .10	− .03
July 19	9011	245	− .28	− .23	− .15
Sept. 2	9056	250	−0.08	−0.27	−0.21

$$\begin{array}{rrrcrl} 10\,x & -0.68\,y & -2.96\,z & = & +1''.20 & x = +0''.056 \\ -0.68 & +5.26 & -0.44 & = & +0.72 & y = +0.121 \\ -2.96 & -0.11 & +1.80 & = & -1.39 & z = -0.213 \end{array}$$

XXXIV. *Washington Prime-Vertical Observations of α Lyrae*, 1882.9–84.6. (See *A.J.* XI, 180, 181.) Observations by Lieuts. TAYLOR, BOWMAN and INGERSOLL. Assumed $\theta = 0^\circ.843$; $T'_0 = 2409079$.

1883-84	t	Obs.	O	C	C′
			″	″	″
Mar. 31	8901	9	+0.21	+0.11	+0.10
Apr. 29	8930	10	+ .11	+ .16	+ .03
May 21	8952	12	+ .08	+ .15	+ .01
July 15	9007	12	+ .11	+ .08	− .15
Sept. 23	9077	9	+ .09	− .08	− .21
Oct. 24	9108	9	− .12	− .13	− .18
Nov. 18	9133	10	− .32	− .16	− .13
Dec. 12	9157	9	− .37	− .16	− .07
Jan. 15	9191	11	+ .03	− .13	+ .04
Jan. 31	9207	9	− .02	− .10	+ .08
Mar. 2	9238	10	+ .01	− .04	+ .17
Apr. 5	9272	10	−0.05	+0.04	+0.21

$$\begin{array}{rrrcrl} 12\,x & +1.83\,y & -0.27\,z & = & +0''.18 & x = +0''.034 \\ +1.83 & +6.61 & +0.83 & = & -0.93 & y = -0.139 \\ -0.27 & +0.83 & +5.10 & = & -0.60 & z = -0.088 \end{array}$$

XXXV. *Washington Transit-Circle Observations of δ and λ Ursae minoris, and 51 H Cephei*, 1880.0–87.0. (See series XXII.) Assumed $\theta = 0^\circ.843$; $T'_0 = 2409079$.

1883-84	t	Obs.	O	C	C′
			″	″	″
Aug. 28	9051	64	−0.04	+0.09	−0.21
Oct. 18	9102	59	− .16	+ .04	− .19
Dec. 12	9157	89	+ .33	− .01	− .06
Feb. 9	9216	69	− .17	− .10	+ .11
Apr. 15	9282	102	− .36	− .08	+ .21
June 23	9351	134	+ .27	+ .01	+ .14
Aug. 26	9415	81	+0.12	+0.09	−0.06

$$\begin{array}{rrrcrl} 7\,x & +0.16\,y & +0.43\,z & = & +0''.34 & x = +0''.016 \\ +0.16 & +3.15 & +0.01 & = & -0.25 & y = -0.075 \\ +0.43 & +0.01 & +3.55 & = & +0.26 & z = +0.069 \end{array}$$

XXXVI. *Almucantar Observations*, 1884–85. (See *A.N.* CXII, 116, and *A.J.* XI, 60.) The residuals used for solution are those for observations after 1884 Nov. 8, on stars south of +15°. Assumed $\theta = 0^\circ.843$; $T'_0 = 2409550$.

1884-85	t	Obs.	O	C	C′
			″	″	″
Nov. 11	9495	35	−0.23	−0.20	−0.21
Dec. 14	9525	15	+ .02	− .15	− .21
Jan. 11	9553	6½	− .25	− .08	− .18
Feb. 17	9590	14	+ .09	+ .03	− .12
Mar. 13	9614	20	− .09	+ .10	− .04
Apr. 13	9645	32	+ .28	+ .18	+ .06
May 21	9683	34½	+ .43	+ .22	+ .16
June 17	9710	17	+0.02	+0.21	+0.20

$$\begin{array}{rrrlr|l}
8\;x & +2.91\,y & +3.38\,z & = & +0.59 & x = +0.039 \\
+2.91 & +3.97 & -0.12 & = & +0.95 & y = +0.201 \\
+3.38 & -0.42 & +4.03 & = & -0.32 & z = -0.092
\end{array}$$

XXXVII. Küstner's *Universal Transit Observations*, 1884–85. (See his Memoir, also *A.J.* XI, 65, 66, and *A.N.* CXXV, 275.) The residuals used are from the place last cited. Assumed $\theta = 0''.843$; $T'_0 = 2409613$.

1884–85	t	Obs.	O ″	C ″	C' ″
Apr. 14	9281	32	—0.07	—0.08	—0.03
May 12	9309	43	+ .05	+ .02	+ .05
Aug. 16	9405	57	+ .23	+ .24	+ .21
Oct. 21	9471	51	+ .16	+ .15	+ .08
Apr. 8	9640	36	— .24	— .23	— .20
May 11	9673	22	—0.20	—0.18	—0.13

$$\begin{array}{rrrlr|l}
6\;x & +2.16\,y & 0.02\,z & = & +0.23 & x = +0.050 \\
+2.16 & +3.42 & +1.30 & = & -0.32 & y = -0.035 \\
-0.02 & +1.30 & +2.58 & = & -0.66 & z = -0.238
\end{array}$$

XXXVIII. *Madison Meridian-Circle Observations*, 1883.5–85.9. (See annual volumes, *A.N.* CXXVII, 99, and *A.J.* XI, 109, 118.) I am inclined to think there may be some form of systematic error, which renders the 1886 and 1887 results inharmonious with the previous years. I have therefore not used them; although the propriety of this course may be doubtful. Assumed $\theta = 0''.813$; $T'_0 = 2409100$.

1884–86	t	Obs.	O ″	C ″	C' ″
Dec. 25	9536	..(1)	—0.27	+0.01	—0.17
Mar. 24	9625	..(3)	+ .27	+ .19	+ .07
May 26	9688	..(2)	+ .22	+ .16	+ .20
June 28	9721	..(5)	+ .25	+ .09	+ .21
Aug. 5	9759	..(5)	+ .16	— .02	+ .17
Sept. 20	9805	..(3)	— .02	— .13	+ .05
Nov. 23	9869	..(4)	— .27	— .20	— .13
Jan. 14	9921	..(2)	—0.28	—0.14	—0.21

$$\begin{array}{rrrlr|l}
25\;x & -8.77\,y & +4.50\,z & = & -0.17 & x = -0.058 \\
-8.77 & +11.40 & -0.13 & = & -2.98 & y = -0.244 \\
+4.50 & -0.13 & +10.60 & = & -2.24 & z = -0.190
\end{array}$$

XXXIX. *Washington Transit-Circle Observations of Polaris*, 1883.4–87.0. (See series XX.) Assumed $\theta = 0''.843$; $T'_0 = 2409506$.

1884–85	t	Obs.	O ″	C ″	C' ″
June 14	9342	34	+0.69	+0.41	+0.15
July 15	9373	34	+ .80	+ .39	+ .08
Aug. 14	9403	29	+ .64	+ .29	— .02
Sept. 14	9434	20	— .08	+ .13	— .12
Oct. 15	9465	23	.00	— .05	— .18
Nov. 15	9496	54	— .93	— .23	— .24
Dec. 15	9526	19	— .47	— .35	— .24
Jan. 14	9556	25	— .22	— .41	— .17
Feb. 14	9587	24	+ .26	— .38	— .10
Mar. 15	9616	13	— .31	— .29	.00
Apr. 15	9647	28	— .43	— .13	+ .09
May 15	9677	13	+ .18	+ .04	+ .17
June 16	9709	19	— .39	+ .22	+ .24
July 15	9738	24	—0.12	+0.35	+0.21

$$\begin{array}{rrrlr|l}
14\;x & +0.06\,y & +0.03\,z & = & -12.12 & x = -0.864 \\
+0.06 & +7.01 & +0.06 & = & -2.17 & y = -0.300 \\
+0.03 & +0.06 & +6.96 & = & -1.95 & z = -0.273
\end{array}$$

XL. Doolittle's *Zenith-Telescope Observations*, 1888. (See series XLI.) This is the second exception mentioned on p. 17, in which the result is not derived from a least-square solution. From the various values of the latitude found in different years by Prof. Doolittle, it is evident that this determination of 1888 must have been made at or near an epoch of minimum, and I have felt at liberty to assume it as such, directly.

XLI. Doolittle's *Zenith-Telescope Observations*, 1889.9–90.9. (See *A.J.* VII, 14, and *A.N.* CXXVIII.) Prof. Doolittle must be regarded as a pioneer in this subject, having devoted himself to it years before the reality of latitude-variations was generally regarded as probable. The accuracy, homogeneity and continuity of his observations, make the series the most valuable of any we possess. I have here employed only the data for 1889 and 1890. It is hoped that he will soon be able to publish the earlier ones, running back to 1876, in a form that may make them similarly available. Assumed $\theta = 0''.813$; $T'_0 = 2411216$.

1889–90	t	Obs.	O	C	C'
Dec. 30	1367	22	—0.18	—0.19	—0.12
Feb. 20	1419	15	— .05	— .02	+ .04
Mar. 23	1450	29	+ .10	+ .09	+ .13
May 19	1507	30	+ .29	+ .21	+ .21
June 18	1537	26	+ .19	+ .25	+ .21
July 29	1578	25	+ .12	+ .20	+ .15
Sept. 13	1624	27	— .01	+ .05	+ .02
Oct. 29	1670	30	— .26	— .11	— .12
Nov. 28	1700	28	—0.13	—0.20	—0.18

$$\begin{array}{rrrlr|l}
9\;x & -0.23\,y & +1.15\,z & = & -0.29 & x = -0.036 \\
-0.23 & +3.01 & +0.13 & = & -0.75 & y = -0.249 \\
+1.15 & +0.13 & +6.01 & = & -0.18 & z = -0.018
\end{array}$$

XLII. *Prague Zenith-Telescope Observations*, 1889.2–91.1. (See *A.N.* CXXVIII.) Observers, Weinek and Gruss. Talcott's method. Assumed $\theta = 0''.843$; $T'_0 = 2411100$.

1889–90	t	Obs.	O	C	C'
Sept. 26	1272	256	+0.115	+0.097	+0.06
Nov. 21	1328	249	.085	— .095	— .10
Jan. 19	1387	269	— .215	— .229	— .21
Mar. 10	1437	297	— .262	— .217	— .20
May 25	1513	289	+ .066	— .002	.01
July 23	1572	288	+ .086	+ .181	+ .15
Aug. 23	1603	288	+ .221	+ .232	+ .20
Oct. 4	1645	282	+0.200	+0.225	+0.21

$$\begin{array}{rrrlr|l}
8\;x & +0.03\,y & -0.52\,z & = & +0.526 & x = +0.050 \\
+0.03 & +3.86 & -0.19 & = & 0.049 & y = -0.025 \\
-0.52 & -0.19 & +1.14 & = & 0.990 & z = -0.234
\end{array}$$

XLIII. *Potsdam Zenith-Telescope Observations*, 1889.2–90.3. (See *A.N.* CXXVIII.) Observer, Schnauder. Talcott's method. Assumed $\theta = 0''.843$; $T'_0 = 2411100$.

1889–90	t	Obs.	O	C	C'
					″
Mar. 18	1080	203	+0.052	−0.034	+0.04
May 15	1138	259	+ .122	+ .156	+ .18
June 18	1172	221	+ .196	+ .225	+ .21
Aug. 1	1219	191	+ .254	+ .227	+ .19
Sept. 21	1267	211	+ .130	+ .122	+ .08
Jan. 5	1373	177	− .202	− .205	− .20
Feb. 16	1415	221	− .241	− .240	− .21
Mar. 30	1457	182	−0.239	−0.185	−0.16

$$\begin{array}{rrrcrcrcr} 8\,x & +1.04\,y & -0.44\,z & = & +0''.085 & & x & = & +0''.002 \\ +1.04 & +3.28 & +0.42 & = & -0.214 & & y & = & -0.035 \\ -0.44 & +0.12 & +4.73 & = & -1.146 & & z & = & -0.239 \end{array}$$

XLIV. *Berlin Zenith-Telescope Observations*, 1889.0–91.4. (See *A.N.* CXXVIII.) Observers, Marcuse and Battermann. Talcott's method. Assumed $\theta = 0''.843$; $T'_0 = 2411400$.

1889–90	t	Obs.	O	C	C'
			″	″	″
Sept. 8	1254	267	+0.184	+0.142	+0.11
Nov. 14	1321	299	− .031	− .051	− .09
Jan. 2	1370	315	− .234	− .173	− .19
Feb. 12	1411	340	− .210	− .210	− .21
Mar. 21	1448	279	− .145	− .180	− .18
May 24	1512	309	− .041	− .018	− .04
July 14	1563	321	+ .119	+ .130	+ .13
Sept. 1	1612	325	+0.173	+0.206	+0.21

$$\begin{array}{rrrcrcrcr} 8\,x & +0.32\,y & +0.84\,z & = & -0''.097 & & x & = & +0''.011 \\ +0.32 & +3.65 & -0.09 & = & -0.105 & & y & = & -0.035 \\ +0.84 & -0.09 & +4.39 & = & -0.895 & & z & = & -0.207 \end{array}$$

XLV. *Pulkowa Prime-Vertical Observations* of 13 *zenithal stars*, 1890.3–91.0. (See *A.N.* CXXVII.) Observer, Wanach. Assumed $\theta = 0.818$; $T'_0 = 2411400$.

1890	t	Obs.	O	C	C'
			″	″	″
May 3	1491	. .	−0.05	−0.12	−0.13
May 18	1506	. .	− .05	− .06	− .09
June 9	1528	. .	− .06	+ .02	− .04
June 21	1543	. .	+ .04	+ .07	+ .04
July 16	1565	. .	+ .19	+ .15	+ .08
Aug. 7	1587	. .	+ .24	+ .21	+ .13
Aug. 27	1607	. .	+ .26	+ .24	+ .17
Sept. 12	1623	. .	+ .25	+ .26	+ .20
Sept. 25	1636	. .	+ .22	+ .26	+ .21
Nov. 24	1696	. .	+0.16	+0.16	+0.18

$$\begin{array}{rrrcrcrcr} 10\,x & +4.02\,y & -5.39\,z & = & -0''.03 & & x & = & -0''.120 \\ +4.02 & +5.23 & -0.74 & = & -0.54 & & y & = & -0.047 \\ -5.39 & -0.74 & +4.77 & = & -0.52 & & z & = & -0.252 \end{array}$$

The material utilized in the foregoing forty-five series aggregates more than thirty-three thousand observations. Of these more than one-third were made in the southern hemisphere, a fact which we owe principally to Cordoba. It comprises the work of seventeen observatories (four of them in the southern hemisphere), with twenty-one different instruments, and by nine distinct methods of observation. Only three of the series (XXI, XXV and XXXV), and these among the least precise intrinsically, give results contradictory of the general law developed in no. 267. This degree of general harmony is indeed surprising, when the evanescent character of the phenomenon under investigation is considered.

The reader has now before him the means for independent scrutiny of the material on which the conclusions already drawn, and those which are to follow, are based. The space taken in the printing may seem unconscionable, but I hope this will be charged to the extent of the evidence collected, and not to diffuseness, or the presentation of needless detail; for I have studiously sought to compress the form of statement without omitting anything essential for searching criticism. That it was important to do this is manifest, since the conclusions, if established, overthrow the existing theory of the earth's rotation, as I have pointed out on p. 21. I am neither surprised nor disconcerted, therefore, that Prof. Newcomb should hesitate to accept some of these conclusions, on the ground (*A.J.* no. 271) that they are in such conflict with the laws of dynamics that we are entitled to pronounce them impossible. He has been so considerate and courteous in his treatment of my work thus far, that I am sure he will not deem presumptuous the following argument in rebuttal.

It should be said, first, that in beginning these investigations last year, I deliberately put aside all teachings of theory, because it seemed to me high time that the facts should be examined by a purely inductive process; that the nugatory results of all attempts to detect the existence of the Eulerian period probably arose from a defect of the theory itself; and that the entangled condition of the whole subject required that it should be examined afresh by processes unfettered by any preconceived notions whatever. The problem which I therefore proposed to myself was to see whether it would not be possible to lay the numerous ghosts — in the shape of various discordant residual phenomena pertaining to determinations of aberration, parallaxes, latitudes, and the like — which had heretofore flitted elusively about the astronomy of precision, during the century; or to reduce them to tangible form, by some simple, consistent hypothesis. It was thought that, if this could be done, a study of the nature of the forces, as thus indicated, by which the earth's rotation is influenced, might lead to a physical explanation of them.

Naturally, then, I am not much dismayed by the argument of conflict with dynamic laws, since all that such a phrase means must refer merely to the existent state of the theory at any given time. When the 427-day period was propounded, it was as inconsistent with known dynamic law as the variation of it now appears to be. Prof. Newcomb's own happy explanation has already set aside the first difficulty, as it would appear, and advanced the theory by an important step. Are we so sure yet of a complete knowl-

edge of all the forces at work as to exclude the chance of a *vera causa* for the second?

As to Prof. Newcomb's first objection, the peculiarity of the equations to which he adverts, — and which was pointed out by Prof. Hall several years ago (*Am. Jour. of Science*, 129), in its bearing upon an analogous case, — was, of course, not out of mind while I was examining the present data; but I drew the conclusion that the results would not be materially influenced by it. In view of the opposite opinion of Prof. Newcomb, the weight of which will necessarily carry with it that of other astronomers, unless it can be met by convincing argument, I beg a suspension of judgement until what follows is carefully weighed against it.

If the variations of latitude obey any regular law, the epochs of maximum and minimum correspond to some function of the time. If the form of this function be either known or assumed, and the amplitude of the variation be alone determined from observation, the resultant values will be unrestricted as to sign, *i.e.*, they will not be subject to the condition of being essentially positive, as in the case where the epochs are also determined from the equations. If there be no actual variation of latitude, *i.e.*, if $r = 0$, the values deduced from a sufficiently large number of series will be indiscriminately positive and negative, and their mean will be zero, the correct value by this hypothesis. If there be a real variation, but a wrong law be assumed, a similar result follows. If, on the contrary, the true law, or a close approximation to it, be assumed, the positive sign will tend to prevail among the deduced values of r, and the strength of this tendency will be greater, the nearer the assumed hypothesis represents the true law, and the more considerable is the quantity sought in proportion to the errors of observation. If the amount of the variation is large with reference to these errors, the values of r will all be positive; but, whatever the proportion may be, the mean of the r's will unrestrictedly represent the true value, if the hypothesis as to the law be nearly correct.

We have, then, in the prevalence of the positive sign among the values of the semi-amplitude, r, found in this manner, by means of the law of equations (3), (4) and (5), and in the failure of any assumption of a uniform period to satisfy this condition, what seems to me a crucial test of the reality of a retardation in the velocity of the polar motion. Let us see how the law in question responds to this test. From the mode of forming the columns O and C', in the tables on pp. 58–62, 65–68, we have the distance between the poles, determined by this method, $r = 0''.22 \frac{O}{C'}$ from each observation-equation; and the most probable value from all the equations of any series,

$$r = 0''.22 \frac{[OC']}{[C'C']}$$

The following table gives the values thus found.

TABLE VI.

Series	No. Eq.	r	Series	No. Eq.	r
I	12	+0.480	XXIII	8	+ [illegible]
II	10	+ .070	XXIV	7	+ .271
III	8	+ .049	XXV	9	— [illegible]
IV	9	+ .070	XXVI	14	+ [illegible]
V	9	+ .072	XXVII	7	+ [illegible]
VI	7	+ .124	XXVIII	7	+ [illegible]
VII	12	+ .282	XXIX	14	+ [illegible]
VIII	8	+ .320	XXX	14	+ [illegible]
IX	10	+ .348	XXXI	9	+ [illegible]
X	9	+ .151	XXXII	14	+ [illegible]
XI	12	+ .170	XXXIII	10	+ [illegible]
XII	15	+ .064	XXXIV	12	+ [illegible]
XIII	7	+ .183	XXXV	7	— [illegible]
XIV	15	+ .021	XXXVI	8	+ .183
XV	8	+ .000	XXXVII	6	+ .277
XVI	8	+ .077	XXXVIII	8	+ .204
XVII	9	+ .169	XXXIX	14	+ .272
XVIII	13	+ .296	XLI	9	+ .257
XIX	7	+ .116	XLII	8	+ .227
XX	11	+ .215	XLIII	8	+ .252
XXI	7	— .066	XLIV	8	+ .215
XXII	7	+0.337	XLV	10	+0.278

Only three of the series, XXI, XXV and XXXV, give negative values, and these are numerically small, and could be converted to positive ones by the mere rejection of a single discordant equation in two cases, and of two in the third. Such a rejection would be entirely justifiable, out of a total of 127 equations, considering the smallness of the quantity under examination, the moderate precision of some of the series, and the very important fact, which I shall endeavor to demonstrate further on, that there are systematic objective deviations from the general law.

The testimony then from this point of view, the correctness of which appears to me unassailable, is overwhelming, unless it can be shown that the hypothesis of a uniform period will produce equally or nearly as harmonious accordance. This cannot be done. I have not carried out the computation in detail, because it is sufficiently manifest that any such attempt would end in complete failure.

But the evidence of variation in the period can be presented more directly, in a way from which I can see no escape. Let us separate the data of Table I, p. 19, into two parts. Take, first, the first thirteen series, the mean epoch of which is —25, by weights. A least-square solution on the hypothesis of a uniform period gives,

$$2396173 + 390.2\,(E + 25)$$

with the following deviations from observation.

TABLE VII.

Series	$O - C$	Series	$O - C$
	d		
I	+ 47	VIII	— 77
II	+ 37	IX	+ 25
III	— 93	X	— 19
IV	— 39	XI	— 2
V	+ 41	XII	+ 30
VI	+ 76	XIII	+ 9
VII	— 85		

From the last thirty-two series, whose mean epoch is + 2, we find similarly,

$$2407061^d + 430^d.2\,(E-2)$$

with the deviations,

TABLE VIII.

Series	O—C	Series	O—C	Series	O—C
	d		d		d
XIV	—25	XXV	–	XXXVI	—89
XV	—26	XXVI	—73	XXXVII	—39
XVI	+27	XXVII	—52	XXXVIII	—71
XVII	+39	XXVIII	—60	XXXIX	+13
XVIII	+58	XXIX	—35	XL	+51
XIX	+12	XXX	—24	XLI	+46
XX	—33	XXXI	+ 3	XLII	+23
XXI	–	XXXII	—55	XLIII	+27
XXII	+ 8	XXXIII	—72	XLIV	+28
XXIII	+18	XXXIV	+26	XLV	+ 9
XXIV	+23	XXXV	–		

Now I can conceive of no principle in construing the evidence, which would lead us to accept the fact that the period during the second interval was about 430 days, without compelling us to admit that during the first interval it was about 390 days; short of rejecting the whole evidence altogether. It ought not to escape attention that each set of observations also contains within itself strong indications of increase in the period, corroborative of that shown by a comparison of the mean results from both. Thus, the first set gives, on the hypothesis of a period varying uniformly with the time,

$$2396129^d + 384^d.6\,(E+25) + 0^d.96\,(E+25)^2$$

and the second,

$$2407031^d + 430^d.7\,(E-2) + 0^d.49\,(E-2)^2$$

both of which expressions will satisfy the observations within the respective groups better than the assumption of a uniform period for each. Further, they give for the length of the period, $384.6+1.92(E+25)$ and $430.7+0.98(E-2)$, respectively; or, for $E=0$, the values 432.6 and 428.7, respectively, — a most striking agreement. Still again, on the hypothesis of a uniform period, required by the accepted theory of the earth's rotation, we have, by a least-square solution of all the data,

$$2406291^d + 409^d\,E$$

giving the following deviations,

TABLE IX.

Series	O—C	Series	O—C	Series	O—C
	d		d		d
I	+267	XVI	—251	XXXI	0
II	+257	XVII	—249	XXXII	— 36
III	+108	XVIII	—199	XXXIII	— 32
IV	+162	XIX	—215	XXXIV	+ 87
V	+242	XX	—248	XXXV	–
VI	+277	XXI	–	XXXVI	— 7
VII	+ 60	XXII	—185	XXXVII	+ 43
VIII	+ 49	XXIII	—133	XXXVIII	+ 11
IX	+132	XXIV	—128	XXXIX	+ 95
X	— 44	XXV	–	XL	+197
XI	— 83	XXVI	—203	XLI	+213
XII	— 70	XXVII	—118	XLII	+190
XIII	—129	XXVIII	—126	XLIII	+194
XIV	—393	XXIX	—101	XLIV	+194
XV	—301	XXX	— 69	XLV	+175

which again proves that the hypothesis in question is irreconcilable with the observations.

The difficulty of maintaining the hypothesis of uniformity of period will be still further increased if the observations before 1840 be taken into consideration; but I do not propose to go into this question until the discussions of BRADLEY'S, BRINKLEY'S, BESSEL'S and the Dorpat observations have been presented. I think these give it the deathblow.

What then are we to conclude? Naturally that the burden of proof is thrown upon theory, to justify itself or remedy its defects. Let us mark here a few steps in the development of the subject, leading up to the present dilemma. The earth of EULER'S analysis was a free, rigid, homogeneous spheroid, whose axis of rotation, if not coincident with the axis of figure, would, — while fixed in space (except by a minute negligible amount, and also ignoring precession and nutation), — revolve about the axis of figure. The daily rate of this motion, which, as regards space, is one of the axis of figure about that of rotation, is fixed by the ratio of the difference of the two moments of inertia to the principal one, and must be $1^\circ.18$, and perfectly uniform. The reliance upon this theory has been heretofore so unquestioning, that every investigator, including BESSEL,* PETERS, NYRÉN and NEWCOMB, has started with this velocity as fundamental, and endeavored merely to find from observation the angular separation of the poles, and their direction at a given time. The results of their investigations were uniformly unsatisfactory; first, because, as Prof. HALL has pointed out, the nature of the equations employed would necessarily give a positive value of the radius of rotation, whether real or not, and the deduced values were not greater than the errors of observation; secondly, because the longitudes of the line joining the two poles, when reduced to a common epoch, were irreconcilable. I think I am not misstating the impression made on the minds of astronomers by these discussions, in saying that they caused general skepticism as to the actuality of this theoretically possible revolution.

The appeal to observation, treated irrespective of theory, in the present series of papers, shows that such a motion really exists, but (a) at a daily rate of but $0^\circ.85$ (for 1875); and (b) that this velocity is subject to a slow retardation, which, in its turn, is not uniform. In but one particular, the direction of the motion, does observation concur with analysis; in the others the divergence is complete.

The result (a) was, at first, pronounced impossible, and is even now so regarded in some quarters, being inconsistent with the above dynamic law. Prof. NEWCOMB, however, soon after found the defect in the theory, as is known, and is now as cordially in favor of the result given by obser-

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* Although PETERS was the first to examine the question thoroughly, it is my impression that BESSEL had previously given it attention, but with data insufficient for a determinate result. I write this from memory, while on my vacation in the country, and cannot verify it.

vation as he was originally against it. But he still urges objection to the result (*b*) on the same ground of dynamic impossibility. Now, may it not reasonably be asked, if the direct deduction from observation has led to the correction of theory in the first particular, is it beyond hope that it may do so in regard to the second? Indeed, if the introduction of the earth's elasticity, or plasticity, into the problem can be made to consist with but a part of the phenomenon, and the other part is equally well proved, must we not infer that the theory in its new form is incomplete, and that some circumstance in the condition of the earth, not yet incorporated in the analysis, may ultimately explain all?

I can see but three ways in which the theory in its present condition can be successfully maintained. It may be contended: —

1. That the material of observation presented in these papers is insufficient, in quantity or quality.
2. That the processes of treatment are erroneous.
3. That the phenomena are misinterpreted, or are due to some other physical cause.

Let us accordingly proceed to bring out various significant aspects of the evidence. It will then be seen whether any of the above objections can be effectively advanced.

The previous remarks have drawn us a little aside the course of answering Prof. NEWCOMB's remaining argument, near the top of p. 50. In view of the results in Table VI it would seem as though his estimates of z must be fallacious. I confess to timidity in following him upon this ground. Its shifting sands give no sure foothold, and make thrust and parry alike uncertain. However, to sustain this rather warlike metaphor, I will make one or two feeble passes of the rapier, and retreat to solid earth. The "systematic errors varying from month to month, and from season to season, with which every one who has discussed meridian-observations is familiar" have been largely and deceptively imposed upon us, in the past, by the very phenomenon we are discussing. I shall be much surprised if in the future our ideas of the amount of the unexplained errors of this sort, comprising all that class of obscure variations apparently dependent on temperature, are not singularly modified thereby. I appeal to examples illustrating this in many of the series here discussed: Greenwich, Radcliffe, Paris, Leyden, Washington, Cordoba, Santiago, Melbourne, Cape of Good Hope. Indeed, instrumental temperature-variation, which, for want of a better known cause, has been made a convenient and universal scapegoat in matters of this kind, is likely to have a great part of its burden lifted hereafter. Again, the methods employed in the previous discussions in assembling the data, have a tendency to eliminate any systematic errors not corresponding to the period of the latitude-variation, so that these partake in this regard of the nature of accidental error.

A demonstration will be given later on, which I think will convince the most skeptical, that the maxima and minima from which the laws of the latitude-variation have been deduced, cannot possibly be attributed to a constant prevailing effect of temperature, or anything dependent on season.

I beg that Prof. NEWCOMB will see nothing dogmatic or presumptuous in the positions taken in this article, although in defensive argument of this kind it is difficult to state clearly reasons for difference of opinion, without appearing so. His sound judgement and broad knowledge — for which no man can have higher admiration than I — give him an overwhelming advantage in the discussion; and I hope yet to see them ranged on the side where the truth as it appears to me lies.

I take this opportunity to make a correction and some additions to the data. Two solutions were made for series I, with different values of θ. By oversight in copying, a wrong selection from these was made on p. 58; the correct one is given below. Also, the results for the Greenwich Transit-Circle are added. The investigations of THACKERAY, DOWNING and VAN DEBARKHUYZEN, apparently showed probability of serious complication from instrumental variations due to temperature. As it was not clear how these could be separated, if they exist, from the change of latitude, I postponed the computations relating to this series until after the articles in nos. 267, 272, and the present number, were prepared. Lest their omission should appear singular, after the remark on p. 86, Vol. XI, they are given here in the same form as the others, assigning series-numbers conforming to the order of the epochs, but with distinguishing index-letters. On account of the large accidental errors with which these observations are affected, the results are not as significant as they might be; but the good accord of three of the four groups with the general law of no. 267 gives room for doubt whether the anomalies, which have heretofore been ascribed to temperature-variation in this instrument, are in reality of that character.

1. *Greenwich Reflex Zenith-Tube Observations of* [illegible], 1837–48. To be substituted for the solution on p. 58. $\theta = 0^{\prime}.923$; $T^{\prime}_{\circ} = 2393880$.

1842–3	t	Obs.	O	C	[illegible]
June 15	4002	59	+0.22	0.00	+0.20
July 15	4032	67	+ .23	+ .17	+ .22
Aug. 15	4063	46	+ .25	+ .31	− .17
Sept. 15	4094	51	+ .13	+ .37	− .00
Oct. 15	4124	56	+ .33	+ .34	− .01
Nov. 15	4155	55	+ .24	+ .23	− .12
Dec. 15	4185	60	+ .05	+ .07	− .20
Jan. 15	4216	54	+ .04	− .12	.21
Feb. 14	4246	17	− .25	− .27	− .16
Mar. 15	4275	18	− .12	− .35	− .08
Apr. 15	4306	53	− .78	.36	+ .04
May 15	4336	61	.50	.20	+ .12
June 15	4367	34	+0.01	0.14	+ .20

$13\,x + 0.16\,y + 0.01\,z = + 5.54 \qquad x = + 0.429$
$+0.16 \quad + 6.56 \quad - 0.01 = - 0.82 \qquad y = - 0.138$
$+0.01 \quad - 0.01 \quad + 6.45 = \quad 2.20 \qquad z = + 0.347$

IX *a*. *Greenwich Transit-Circle Observations of Polaris*. 1851.0–58.6. (From Stone's nutation-determination. *Memoirs R. A. S.*, XXXVII, 86ff.) Assumed $\theta = 0''.911$; $T'_0 = 2398112$.

1851.5	*t*	Obs.	*O*	*C*	*C′*
Apr. 15	8324	92	—0.06	+0.04	+0.05
May 15	8354	75	+ .01	+ .04	— .04
June 15	8385	96	— .10	— .02	— .14
July 15	8415	92	— .05	— .05	— .20
Aug. 15	8446	76	— .07	— .07	— .22
Sept. 15	8477	96	— .06	— .07	— .19
Oct. 15	8507	93	— .03	— .05	— .14
Nov. 15	8538	101	+ .13	— .03	— .01
Dec. 15	8568	96	— .09	+ .04	+ .09
Jan. 15	8599	52	— .09	+ .04	+ .17
Feb. 15	8630	76	+ .05	+ .06	+ .21
Mar. 15	8658	86	+ .13	+ .07	+ .20
Apr. 15	8689	95	+0.22	+0.06	+0.15

$$\begin{array}{rrrcr|l} 13\,x & -0.04\,y & -0.07\,z & = & -2''.84 & x = -0''.219 \\ -0.04 & +6.46 & -0.01 & = & -0.14 & y = -0.023 \\ -0.07 & -0.01 & +6.54 & = & -0.12 & z = -0.067 \end{array}$$

XII *a*. *Greenwich Transit-Circle Observations of Polaris*, 1858.7–65.7. (See series IX *a*.) Assumed $\theta = 0''.911$; $T'_0 = 2404211$.

1861–62	*t*	Obs.	*O*	*C*	*C′*
Nov. 15	1095	97	+0.13	—0.01	+0.07
Dec. 15	1125	70	— .08	.00	— .04
Jan. 15	1156	105	+ .08	+ .01	— .13
Feb. 15	1187	106	— .04	+ .02	— .20
Mar. 15	1215	104	— .07	+ .02	— .22
Apr. 15	1246	90	— .04	+ .02	— .19
May 15	1276	61	— .01	+ .01	— .12
June 15	1307	63	+ .25	.00	— .03
July 15	1337	67	— .06	— .01	+ .07
Aug. 15	1368	70	+ .07	— .01	+ .16
Sept. 15	1399	74	— .33	— .02	+ .24
Oct. 15	1429	77	— .01	— .02	+ .24
Nov. 15	1460	72	+0.07	—0.02	+0.16

$$\begin{array}{rrrcr|l} 13\,x & -0.02\,y & +0.04\,z & = & +0''.71 & x = +0''.057 \\ -0.02 & +6.46 & +0.01 & = & +0.01 & y = +0.002 \\ +0.04 & +0.01 & +6.53 & = & +0.13 & z = +0.020 \end{array}$$

XXII *a*. *Greenwich Transit-Circle Latitudes*, 1868.0–73.0. (From Downing's paper, *Mo. Not. R. A. S.*, XL, 431.) Assumed $\theta = 0''.870$; $T'_0 = 2404062$.

1870	*t*	Obs.	*O*	*C*	*C′*
Jan. 5	4068	. .	—0.25	—0.27	—0.22
Mar. 6	4128	. .	— .33	— .19	— .12
May 3	4186	. .	+ .17	+ .03	+ .07
June 13	4227	. .	+ .10	+ .18	+ .17
July 25	4269	. .	+ .41	+ .27	+ .22
Sept. 6	4312	. .	+ .01	+ .25	+ .17
Nov. 5	4372	. .	+ .24	+ .06	.00
Dec. 25	4422	. .	—0.17	—0.14	—0.15

$$\begin{array}{rrrcr|l} 8\,x & +0.13\,y & -0.69\,z & = & -0''.65 & x = -0''.103 \\ +0.13 & +3.88 & -0.24 & = & -0.18 & y = -0.060 \\ -0.69 & -0.24 & +4.12 & = & -1.02 & z = -0.268 \end{array}$$

XXVI *a*. *Greenwich Transit-Circle Latitudes*, 1873.0–78.0. (See series XXII *a*.) Assumed $\theta = 0^\circ.849$; $T'_0 = 2406150$.

1875	*t*	Obs.	*O*	*C*	*C′*
Jan. 1	5889	. .	—0.06	—0.07	+0.17
Mar. 2	5950	. .	+ .19	+ .18	+ .21
May 5	6014	. .	+ .20	+ .29	+ .10
July 3	6073	. .	+ .44	+ .18	— .09
Aug. 28	6129	. .	+ .19	— .05	— .21
Oct. 31	6195	. .	— .10	— .26	— .18
Dec. 27	6250	. .	—0.24	—0.27	—0.02

$$\begin{array}{rrrcr|l} 7\,x & -0.04\,y & +0.10\,z & = & +0''.44 & x = +0''.063 \\ -0.04 & +3.54 & -0.04 & = & -0.91 & y = -0.258 \\ +0.10 & -0.04 & +3.46 & = & -0.46 & z = -0.138 \end{array}$$

The following supplies the data corresponding to Tables I and II; $\frac{\lambda}{\theta}$, of course, being $= 0$.

Series	*r*	*T′*	*E*	Observed *T*	O—C III
I	0″.371	1842 Mar. 9	—31	239 3904	+65ᵈ
IX *a*	.071	1851 Sept. 1	19	239 8463	+21
XII *a*	.020	1861 Sept. 3	12	240 1022	(—192)
XXII *a*	.275	1870 Jan. 13	— 5	240 4076	+14
XXVI *a*	0.292	1875 Nov. 30	0	240 6223	+73

ELEMENTS OF COMET *a* 1892 (*SWIFT*).

BY F. GERTRUDE WENTWORTH.

The following orbit was computed from places corrected for aberration and parallax, for Mar. 7, May 4 and June 29, based on observations by Profs. Coit, Frisby, Barnard, Wilson, and Miss Whitney. The interval of 114 days comprises a geocentric arc of 108° longitude and 45° latitude, and an anomaly of 114°. The trivial deviation of the middle place, $-2''.4$ in λ, $-1''.2$ in β, (C—O), proves that the orbit is sensibly parabolic, thus settling the doubt which has been raised on this point.

ELEMENTS.

$$T = 1892 \text{ Apr. } 6.66515 \text{ Gr. M.T.}$$

$$\left.\begin{array}{rl} \omega = & 24^\circ\ 31'\ 59''.59 \\ \Omega = & 240\ \ 55\ \ 29.73 \\ i = & 38\ \ 42\ \ 45.86 \end{array}\right\}1892.0$$

$$\log q = 0.0115676$$

CONTENTS.

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LATITUDE-DETERMINATION AT THE SAYRE OBSERVATORY.

By C. L. DOOLITTLE.

The latitude operations which have been carried on at this place consist of two parts, which are in a manner independent of each other, and may be considered separately.

First, observations upon a list of sixty pairs of stars, extending in time from 1876 to 1890 inclusive.

Secondly, a list of 109 pairs observed 1889–90.

Sixteen pairs were common to both star lists, and in what follows will be included in both parts of the discussion.

The instrument was the Zenith-Telescope.

I.

The old list will be first considered. Communications upon the results obtained have appeared in the *Astronomische Nachrichten*, nos. 2260 and 3060, and the *Astronomical Journal*, no. 146.

The distribution of the observations was as follows:

Year	Obs.	Year	Obs.
1876	141	1886	165
77	178	88	121
78	12	89	17
1885	115	1890	393

in all, 1142. A number of the older observations having large level corrections were excluded, for reasons fully stated in *Astronomische Nachrichten*, no. 3060.

I wish it understood that a great degree of accuracy is not claimed for the old observations. For reasons partly due to the instrument, and partly to my want of experience at that time, the probable error of a single determination is large. The values of this quantity, as found from the various series, are as follows:

1876	$\varepsilon = 0.578$
1877	.457
1885–86	.407
1888	.366
1889–90	0.234

The 1142 separate determinations have been condensed to form the 344 values which follow. A much greater concentration would have resulted from a combination of the results from different pairs of stars obtained at about the same time, but it was thought best to exhibit these separately.

The weights were found from the formula,

$$p = \frac{n}{100\,\varepsilon^2}$$

except in case of 1888, which was given half weight, the series not having been completed.

B.A.C.	No.	Epoch	φ	$\sqrt{p}$	B.A.C.	No.	Epoch	φ	$\sqrt{p}$	B.A.C.	No.	Epoch	φ	$\sqrt{p}$
2786	1	76.25	4.33	0.17	2953	1	76.25	4.90	0.17		5	86.29	3.71	[illegible]
2792	1	77.27	3.38	.22	2982	2	77.27	3.40	.31		4	90.25	3.28	[illegible]
	2	78.22	2.98	.31		2	78.22	4.18	.31					
	3	86.28	3.32	0.42		5	86.29	3.49	.55	3199	1	76.28	3.92	0.17
	7	90.26	3.49	1.13		5	90.27	3.49	.96	3303	4	77.30	4.23	.44
	3	90.83	2.17	0.74		4	90.84	3.36	.85		2	78.22	3.24	[illegible]
	4	90.90	2.94	0.85		3	90.89	3.45	0.74		3	86.32	3.52	.42
											3	90.27	3.25	0.74
2849	3	76.27	3.95	0.30	2984	2	76.28	3.73	0.24					
2880	2	77.27	4.72	.31	3075	1	77.29	4.56	.22	3371	3	76.26	2.74	[illegible]
	2	78.22	3.72	.31		4	78.22	3.26	.44	3425	3	77.29	3.73	[illegible]
	3	86.28	3.57	0.42		3	90.25	3.39	0.74		5	86.29	3.64	[illegible]
	8	90.26	3.38	1.21							4	90.25	2.58	[illegible]
	4	90.84	3.40	0.85	3178	2	76.26	3.31	0.24					
	4	90.90	2.76	0.85	3218	2	77.29	4.59	0.31					

B.A.C.	No.	Epoch	ς	$\sqrt{p}$
3496	3	76.28	3.17	0.30
3531	3	77.27	3.84	0.38
	6	86.29	2.94	.60
	4	90.25	3.18	0.85
3652	2	76.28	3.79	0.24
3708	1	77.29	3.71	0.41
3748	2	76.27	3.28	0.24
3777	2	77.27	2.37	.31
	5	86.29	3.39	.55
	3	90.26	3.29	.74
	1	90.34	3.71	0.43
3838	3	76.28	3.01	0.30
3864	4	77.32	1.05	.44
	5	86.29	3.72	.55
	3	90.26	3.65	.74
	2	90.32	3.75	0.60
3877	3	77.33	3.59	0.38
3911	3	86.36	3.01	.42
	5	89.95	2.93	0.96
	7	90.37	3.48	1.13
3973	3	76.29	3.60	0.30
4010	3	77.27	1.54	.38
	2	86.36	3.16	0.35
4123	4	76.30	3.91	0.35
4144	4	77.29	3.62	.44
	4	86.40	3.27	.49
	3	89.97	3.07	.74
	1	90.05	2.65	0.43
	6	90.38	3.39	1.05
4222	3	76.28	3.25	0.30
4267	3	77.31	4.17	.38
	1	86.31	2.64	.24
	4	86.40	2.78	.49
	1	90.25	2.53	.43
	3	90.34	3.02	0.74
4239	1	76.29	2.65	0.17
4271	4	77.27	3.69	.22
	2	77.40	3.46	.31
	1	86.34	2.31	.25
	4	86.41	2.68	.49
	3	89.99	2.83	.74
	2	90.06	2.73	.60
	3	90.38	3.66	.74
	4	90.42	3.15	0.86
4300	2	76.28	3.85	0.24
4338	3	77.33	4.52	.38
	4	86.42	3.95	.49
	1	90.25	3.67	.43
	2	90.34	3.83	0.60
4477	4	76.28	4.62	0.34
4498	2	77.33	4.75	.31
	1	86.31	4.86	.26
	5	86.42	4.05	0.55

B.A.C.	No.	Epoch	ς	$\sqrt{p}$
	1	90.25	4.88	0.43
	2	90.33	4.20	0.60
4713	2	76.29	3.70	0.21
4733	3	77.30	3.27	.38
	1	77.47	3.30	.22
	5	86.44	2.55	.55
	2	90.25	2.81	.60
	2	90.32	3.09	0.60
4804	2	76.30	2.60	0.24
4808	3	77.30	4.61	.38
	5	86.44	2.62	.55
	2	90.06	3.30	.60
	3	90.11	3.43	0.74
	6	90.17	3.50	1.05
4826	1	76.29	3.73	0.17
4876	2	77.30	3.03	.31
	4	77.47	1.35	.22
	3	86.13	3.16	.42
	3	90.26	3.26	.71
	2	90.32	3.37	0.60
4942	3	76.29	3.44	0.30
4958	1	77.34	5.51	.22
	1	77.47	3.86	.22
	5	86.44	3.16	.55
	3	90.26	3.49	.74
	2	90.32	3.52	0.60
5084	1	76.31	4.66	0.17
5157	4	77.27	1.53	.22
	3	77.44	3.33	.38
	4	86.15	3.11	.49
	4	90.27	3.76	0.85
5115	2	76.30	1.12	0.24
5187	2	76.14	3.70	.24
	2	77.30	1.16	.31
	2	77.41	3.70	.31
	5	86.49	3.32	.55
	1	90.34	3.51	.43
	2	90.52	3.30	0.60
5194	3	77.14	3.33	0.38
5285	5	86.44	2.72	.55
	3	90.52	3.82	0.74
5271	2	77.30	2.87	0.31
5295	1	77.42	2.39	.22
	5	86.49	3.86	0.55
	6	90.12	3.11	1.05
	1	90.19	2.93	0.43
	4	90.50	3.26	.85
	5	90.56	3.15	0.96
5466	1	76.31	4.50	0.17
5512	1	76.61	2.20	.17
	1	77.28	3.83	.22
	1	77.61	4.28	.22
	5	86.45	3.20	0.55

B.A.C.	No.	Epoch	ς	$\sqrt{p}$
	3	90.11	3.34	0.74
	2	90.19	3.70	0.60
	6	90.53	3.58	1.05
	1	90.59	3.87	0.85
5523	1	76.31	4.52	0.17
5617	1	77.34	3.76	.22
	4	77.61	3.92	.44
	5	86.50	4.29	.55
	4	90.26	3.90	0.85
5596	2	76.64	3.99	0.24
5693	2	77.27	1.04	.31
	1	77.61	1.98	.22
	5	86.18	4.06	.55
	3	90.29	3.68	.74
	2	90.49	3.70	0.60
5711	1	76.31	3.96	0.17
5801	2	76.61	5.31	.24
	1	77.28	5.06	.22
	2	77.59	4.82	.31
	5	86.19	3.09	.55
	5	86.64	3.95	.55
	1	90.30	4.20	.43
	4	90.49	3.92	0.85
5874	1	76.34	1.73	0.17
5944	2	76.61	1.13	.22
	1	77.27	2.06	.22
	4	77.60	4.39	.44
	2	86.49	4.43	.35
	5	86.61	3.98	.55
	1	90.30	3.88	.43
	4	90.49	3.80	0.85
5941	2	76.64	3.57	0.24
6006	3	77.63	4.45	.38
	5	86.50	3.16	.55
	4	90.27	3.52	.85
	4	90.60	3.39	0.96
	6	90.66	3.42	1.05
6005	1	76.31	4.10	0.17
6079	3	76.61	1.25	.30
	3	77.62	4.25	.38
	5	86.49	3.50	.55
	1	90.30	3.84	.43
	4	90.49	3.77	0 85
6089	2	76.60	2.86	0.24
6114	1	77.63	4.49	0.22
6101	5	77.61	4.46	0.49
6206	5	86.49	3.31	.55
	2	88.69	3.57	.27
	4	90.49	3.69	0.85
6231	1	76.31	4.20	0.17
6318	4	76.61	3.52	.35
	4	77.60	4.71	.44
	5	86.50	3.21	0.55

B.A.C.	No.	Epoch	ς	$\sqrt{p}$	B.A.C.	No.	Epoch	ς	$\sqrt{p}$	B.A.C.	No.	Epoch	ς	$\sqrt{p}$
	4	88.69	3.11	0.39	6901	5	76.61	2.79	0.39		5	90.54	3.32	0.96
	1	90.33	3.21	.43	6970	4	77.60	4.25	.44					
	4	90.49	3.50	0.85		5	85.72	3.84	.55	7679	3	76.61	4.03	0.30
						5	88.68	3.37	.43	7765	3	77.76	4.95	.38
6421	1	76.31	5.67	0.17		5	90.49	3.72	0.96		6	85.73	4.68	.60
6497	1	76.61	3.02	.17							5	88.72	4.00	.45
	1	77.63	3.18	.22	7073	3	76.61	3.33	0.30		4	90.56	4.40	0.86
	4	86.50	4.15	.49	7161	2	77.62	4.02	.34					
	4	85.73	4.17	.49		5	85.73	4.24	.55	7706	3	76.61	3.58	0.30
	4	88.70	3.48	.39		5	88.68	3.11	.43	7778	1	77.77	3.76	.22
	5	90.50	4.09	0.96		4	90.49	3.05	0.84		5	85.74	3.33	.55
											5	88.74	2.94	.43
6476	2	76.61	2.85	0.24	7084	3	76.61	4.40	0.30		2	90.57	3.30	.60
6491	3	77.62	4.89	.38	7171	2	77.62	4.20	.31		3	90.61	3.23	0.74
	5	85.74	3.85	.55		4	85.74	3.66	.49					
	4	88.72	3.42	.39		5	88.73	3.52	.43	7843	4	76.61	3.35	0.35
	2	90.31	3.29	.60		4	90.53	3.74	0.86	7882	2	77.75	4.02	.34
	4	90.37	3.54	.85							6	85.73	3.86	.60
	4	90.69	3.45	.85	7206	3	76.60	3.96	0.30		4	88.66	3.48	0.39
	5	90.75	3.47	0.96	7311	3	77.61	3.74	.38		6	90.57	3.94	1.05
						5	85.73	3.47	.55					
6528	3	76.61	3.20	0.30		5	88.68	2.80	.43	8034	3	76.61	3.35	0.30
6612	4	77.60	3.85	.44		5	90.50	3.29	0.96	8077	1	77.58	5.21	.22
	3	86.50	3.20	.42							3	77.76	4.22	.38
	4	85.72	3.42	.49	7356	2	76.60	3.93	0.24		5	85.73	3.57	.55
	5	88.69	2.85	.43	7377	2	77.60	4.09	.31		4	88.66	3.19	.39
	4	90.53	3.64	0.85		4	85.72	4.06	.49		4	90.59	3.50	.85
						5	88.68	2.40	.43		1	90.67	2.82	0.43
6585	2	76.61	2.93	0.24		3	90.49	3.40	.74					
6625	3	77.62	4.49	.38		2	90.53	3.35	0.60	8052	4	76.61	3.64	0.17
	5	85.75	4.16	.55						8083	2	77.77	3.10	.31
	5	88.73	3.33	.43	7380	3	76.61	4.17	0.30		5	85.77	3.26	.55
	4	90.49	3.22	0.85	7438	3	77.61	3.69	.38		5	88.74	2.48	.43
						5	85.74	3.08	.55		5	90.64	2.82	0.96
6697	3	76.61	4.17	0.30		5	88.73	2.54	.43					
6740	4	77.61	4.36	.44		5	90.47	3.64	.96	8195	3	76.61	3.59	0.30
	5	85.73	3.87	.55		5	90.81	2.89	.96	8229	5	77.76	4.62	.49
	5	88.69	3.45	.43		5	90.89	2.93	0.96		5	85.73	4.64	.55
	3	90.34	3.76	.74							5	88.68	3.54	0.43
	4	90.39	3.92	.86	7453	3	76.61	3.12	0.30		6	89.93	3.21	1.05
	3	90.71	3.30	.74	7501	4	77.61	4.54	.44		1	90.54	3.61	0.43
	4	90.75	3.71	.85		4	85.73	3.14	.49		6	90.56	3.49	1.05
	5	90.81	3.22	0.96		5	88.68	2.50	.43		7	90.92	3.21	1.15
						5	90.51	3.25	0.96					
6784	2	76.60	4.35	0.24						8272	3	76.61	3.31	0.30
6830	2	77.62	3.84	.31	7561	3	76.60	3.82	0.30	8314	4	77.76	4.15	.44
	5	85.73	3.84	.55	7597	2	77.60	4.98	.31		5	85.73	3.54	.55
	5	88.68	3.02	0.43		3	85.73	3.72	.42		4	88.68	3.06	.39
	6	90.38	3.40	1.05		5	88.68	2.41	0.43		4	90.62	3.74	0.85
	5	90.73	3.32	0.96		6	90.48	3.57	1.05					
	6	90.80	2.88	1.05		3	90.86	2.88	0.74	8310	2	76.61	2.51	0.24
						5	90.90	3.08	0.74	8324	1	77.59	4.74	.22
6789	2	77.60	4.45	0.31							4	77.77	[illegible]	.44
6836	5	85.74	2.66	.55	7571	3	76.61	4.63	0.30		5	85.77	[illegible]	.55
	5	88.73	2.62	.43	7643	2	77.77	4.55	.31		5	88.73	[illegible]	.43
	5	90.49	3.19	0.96		5	85.75	4.19	.55		1	[illegible]	2.61	.43
						5	88.73	3.25	0.43		[illegible]	[illegible]	[illegible]	0.74

Perhaps it should be stated that the declinations are those of Boss. When not taken directly from his catalogue they were carefully reduced to the same system. However, as this was done fifteen years ago, some of them might be greatly improved by a rediscussion. Probably for present purposes some system of adjustment [illegible]

have been employed with advantage. It has not been done, however.

Let $\varphi_0 =$ an assumed value of the latitude for 1890.0,
$\varphi_0 + x =$ true value for this epoch.

Then the value of φ for any epoch t is assumed to be of the form $\varphi = \varphi_0 + x + (t - 1890)y + \gamma \cos(R + mt)$.

Expanding the last term and writing

$$\begin{aligned} \gamma \cos R &= z \qquad & \cos mt &= C \\ -\gamma \sin R &= w \qquad & \sin mt &= D \end{aligned}$$

each of the above values gives us an equation of the form

$$\sqrt{p}\,(x + Ty + Cz + Dw = n).$$

If we knew the velocity with which the axis of revolution revolves about the geometrical axis, the coefficients C and D would be known, and the solution of these equations would be a simple matter.

For the results of various hypothesis tested about one year ago the reader is referred to *A.N.* 3060.

Assuming CHANDLER's hypothesis as given in No. 267 of this Journal, the formula for the latitude at any epoch t becomes,

$$\varphi = 40^\circ\ 36'\ 23''.287 - 0''.0182(t - 1890) \\ - 0''.255 \cos\left[75^\circ.4 + (t - T)\,\theta\right]$$

CHANDLER's notation being employed. The value of θ for 1890 is 0°.797.

From my equations $T = 1890$ 45 days.

CHANDLER's formula gives $T = 1890$ 19 days.

The value of $[pvv]$ from this hypothesis is 17″.91.

The smallest value obtained by any other hypothesis was 18″.53.

The secular term, however, remains, and is in fact somewhat larger than that found before. It is evidently not possible to represent the data completely by any single term of short period. The mean value of φ from all observations of 1876, 1877 and 1878 gives φ 23″.905, while the maximum value from the above formula for 1890 is 23″.512.

As every effort has been made to free the data from systematic errors the persistence of this term would seem to be of some significance.

II.

In the summer of 1889 arrangements were made for carrying out a more elaborate system of latitude-observation than had been undertaken previously. The old list was not well adapted to this purpose, for different reasons. Moreover a number of pairs had already become unavailable through precession, and others were approaching the limit. Accordingly a new list of 109 pairs, embracing the entire 24 hours of right-ascension, was prepared. This list included 16 pairs found in the old one. The remaining stars of the old list were observed in connection with the new one for the purpose of rigorously connecting the two series. These results have been given above.

The micrometer-slide was fitted with five threads, numbered consecutively. The difference between consecutive threads was approximately ten revolutions of the screw. Only threads II, III and IV were ever employed, the bisection being made with III when the difference of zenith-distance was less than twenty revolutions of the screw. The distances between these threads were determined by placing them in succession tangent to a fixed thread in the field. Frequent repetitions of the process were necessary, as the values were not quite constant.

The value of one revolution of the screw, together with the temperature-coefficient, were determined from observed transits of circumpolar stars near elongation. Thirty-seven series at different times throughout the year gave

$$R = [50''.5022 \pm ''.0027] - [''.00037 \pm ''.00026]\,[F - 45^\circ]$$

F being the reading of a Fahrenheit thermometer.

Through the courtesy of Captain McNAIR and Prof. HARKNESS of the U.S. Naval Observatory, I was enabled to employ the measuring engine of that institution in an elaborate series of measurements of the screw, for the investigation of progressive and periodic errors.

The observations extend from 1889 Dec. 1 to 1890 Dec. 13; each pair, with two exceptions, being observed both evening and morning. Only one bisection was usually made as the star crossed the field; the level (there was only one) was also read but once, and in most cases after the bisection. The entire number of determinations of the latitude is 1145, 824 from evening and 621 from morning observations.

As the immediate object is the collection of data for a discussion of the variations of latitude, extreme accuracy in the values of the declinations employed is not very important. An investigation of these, however, formed a part of the original plan, and a considerable amount of material has been collected for this purpose. This material has been utilized in part, and with a few exceptions the preliminary declinations employed probably differ but little from those values which would be obtained from a more complete discussion, but they have not been reduced to a homogeneous system.

With these preliminary declinations the latitudes were computed and a series of adjustments carried out, after a manner analagous to that employed elsewhere. For this purpose the observations were divided into groups, as shown in the following table:

	P. M.	A. M.
	h h	h h
1889 Dec. 1 – Dec. 28	22.3 – 3.1	9.8 – 12.6
1890 Jan. 14 – Feb. 6	1.5 – 5.4	12.0 – 15.9
Feb. 8 – Feb. 26	2.9 – 6.1	14.0 – 16.6
Mar. 6 – Apr. 5	5.1 – 9.2	15.6 – 18.5
April 7 – April 30	7.9 – 10.7	16.7 – 19.6
May 2 – May 31	10.1 – 13.2	18.6 – 20.8
June 1 – June 29	12.3 – 16.7	20.1 – 23.0
July 5 – July 31	11.6 – 17.6	22.1 – 1.0
Aug. 3 – Aug. 31	16.1 – 18.9	0.6 – 4.1
Sept. 1 – Sept. 29	17.5 – 20.5	2.3 – 6.2
Oct. 1 – Oct. 31	18.9 – 21.6	4.2 – 9.0
Nov. 1 – Nov. 30	19.5 – 0.5	6.5 – 10.3
1890 Dec. 3 – Dec. 13	23.4 – 0.5	8.8 – 10.3

Operations were begun by taking the mean of all latitudes in the two November groups, these being more numerous than in the case of any other pair of groups. The difference between this mean value and the value deduced from each pair of stars separately, gave the first approximation to the correction of the half-sum of the declinations. These corrections then gave the means for adjusting the overlapping groups to the same system. Reference to the table will show that these include either evening or morning groups, and in some cases both, as follows: Dec. 1889; March, April, May, June, July, September, October and December, 1890.

Corrections were in a like manner obtained by carrying on the adjustment from group to group, sometimes through both evening and morning observations, sometimes employing only one.

In this way a first approximation was obtained. For the second approximation the mean value of the latitude was obtained from each group separately, after applying the corrections already derived. The mean of the morning and evening values was assumed as the value of the latitude for each pair of groups, equal weight being given to each. The correction to the half-sum of the declinations for each pair was then derived from all of the observations on this pair, by taking the difference between the individual values in each group and the mean value of the latitude for that group. The mean of all these individual values formed the second approximation to the required correction of the half-sum of the declinations. As many pairs are found in four, and in some cases five, different groups, it would seem that this process should pretty effectually eliminate errors of a systematic character.

The operation was repeated for a third, and in some cases for a fourth approximation, when the adjustment was found complete: that is to say, a farther repetition did not show an additional correction of as much as one hundredth of a second.

It should be said that a small constant correction was applied to all values in order to make the algebraic sum of all corrections practically zero.

The following are the final values of the latitude obtained from the different groups:

A

		° ′ ″	P.M. — A.M.
1889	Dec.	10 36 23.129	0.031
1890	Jan.	3.330	+ .017
	Feb.	3.400	— .033
	Mar.	3.527	— .007
	April	3.649	— .027
	May	3.512	+ .019
	June	3.529	— .087
	July	3.539	+ .010
1890	Aug.	10 36 23.291	+0.026
1890	Sept.	10 36 23.267	+0.102
	Oct.	3.152	— .050
	Nov.	3.081	.004
1890	Dec.	10 36 22.950	0.099

Among the 109 pairs were a number of large zenith-distance, which it was thought might be of service in determining whether any systematic difference in refraction existed between the north and south stars.

There were also a few pairs for which the difference zenith-distance was 20′ or more.

A computation has been made excluding all pairs whose zenith-distance exceeds 30°, or whose micrometer-correction exceeds 20′. In deriving the values of the latitude from the 83 pairs which remain, an independent adjustment of the declinations was made, so that the results are entirely independent of the stars excluded. These values are as follows:

B

		° ′ ″	P.M. — A.M.
1889	Dec.	10 36 23.133	—0.027
1890	Jan.	3.350	+ .136
	Feb.	3.411	— .002
	Mar.	3.503	+ .016
	April	3.616	— .006
	May	3.552	+ .032
	June	3.576	— .072
	July	3.531	— .020
	Aug.	3.330	+ .060
	Sept.	3.256	+ .143
	Oct.	3.157	— .026
	Nov.	3.101	— .032
1890	Dec.	10 36 22.934	—0.037

The differences between the values *A* and *B* are for the most part quite small, that for June being greatest, 0″.047. This close agreement would seem to show that no considerable errors due to refraction or temperature were present.

In examining the series *A* and *B*, the sudden drop in the value for August, after remaining nearly constant for five months, is very noticeable. Referring to the table (p. 76), it will be seen that the declinations employed in the afternoon observations of August are the same as those used in the morning observations of March and April; while those employed in the morning work of August are the same as those used in the evening work of Dec. 1889, Jan. and Feb. 1890. An examination of these different values, together with the smallness of the difference between the morning and evening values for August, will show that this sudden drop is not due to the declinations.

The tabular statement which follows gives the value of the latitude from each day's observations, those for evening and morning being given separately:

Date		P.M.	Obs.	A.M.	Obs.
1889 Dec.	1	3.15	17		
	2	3.30	1		
	4	3.39	9		
	6	2.96	16		
	7	3.07	16	3.18	7
	9	3.02	10	3.17	7
	11	2.97	19	2.90	9
	13			3.23	6
	23			3.06	6
	26			3.35	11
	27	3.24	5	2.65	1
	28	3.18	7		
1890 Jan.	14	3.20	4		
	17	3.15	5		
	18			3.26	11
	21			3.12	2
	27			3.27	9
	28	3.50	5	3.31	9
Feb.	5	3.24	12		
	6	3.51	11	3.39	12
	8			3.13	12
	9	3.13	6		
	10	3.38	11		
	12	3.41	15		
	15			3.47	9
	16			3.36	1
	18			3.29	6
	20			3.50	7
	22	3.19	6		
	26	3.20	8		
Mar.	6	3.56	8		
	7	3.57	8		
	8	3.69	10	3.57	6
	9			3.53	5
	17	3.38	2		
	18	3.11	8		
	23	3.14	3		
	24	3.56	2		
	28	3.42	3		
	29	3.19	8		
Apr.	1	3.71	6	3.70	5
	2	3.62	7	3.37	7
	3	3.62	3		
	4	3.48	1		
	5	3.52	11	3.54	9
	7	3.10	3	3.61	1
1890 Apr.	10	3.19	1	3.16	3
	11	3.73	5	3.87	8
	12	3.46	8	3.64	9
	16	3.83	7		
	18	3.80	8	3.92	3
	21	3.72	6		
	25	3.28	3		
	28	3.60	6	3.30	2
	30	3.36	5	3.26	1
May	2	3.83	3		
	5	3.37	6		
	8	3.31	1	3.72	6
	11	3.79	5		
	12	3.64	6		
	15			3.49	7
	16	3.60	5		
	17			3.70	9
	20			3.57	2
	21	3.67	5		
	22	3.51	7	3.20	7
	27			3.48	7
	28			3.57	6
	31	3.31	5		
June	1	3.53	7		
	3	3.17	7		
	8	3.73	8		
	11			3.54	4
	15			3.38	9
	18			3.63	7
	19	3.40	6	3.58	6
	20	3.61	6		
	25	3.71	11	3.53	8
	26	3.52	9	3.47	6
	27	3.53	5		
	29	3.25	11	3.61	7
	30	3.18	9	3.93	5
July	5	3.86	11	3.67	6
	6	3.57	4	3.44	7
	18	3.38	1	3.55	9
	19	3.75	7	3.55	2
	20	3.90	7	3.50	11
	21			3.51	9
	22	5.13	8	3.64	8
	30	3.25	3		
	31	3.16	7	2.98	1
Aug.	3	3.53	5		
1890 Aug.	6	3.52	7	3.44	9
	9	3.00	7		
	10			3.55	6
	14	3.26	3	3.21	12
	15	3.39	8		
	20	3.36	6		
	23	3.02	8	3.09	11
	24	3.52	6		
	27	3.22	5	3.28	9
	30	3.32	6	3.28	10
	31			3.23	13
Sept.	1	3.57	8	3.16	7
	2			3.40	9
	7	3.25	6		
	18	3.50	11	3.16	8
	19	3.16	11		
	21			3.66	5
	22			3.33	9
	23	2.81	5	2.93	10
	25	3.31	8		
	28	3.43	10	3.11	10
	29	3.27	10		
Oct.	4			3.12	13
	8	3.39	10	3.31	10
	11	2.89	9	3.05	14
	15	3.05	11		
	17			3.35	11
	21	3.12	10	3.18	11
	30			3.13	11
	31	3.19	10	3.15	9
Nov.	1	3.11	12		
	4			3.11	11
	5			3.14	15
	13	3.06	14	3.05	12
	14	3.01	15		
	21	3.22	16		
	22	3.19	18	2.92	3
	24	2.96	16		
	25			3.07	1
	27			3.08	6
	28	3.14	14	2.95	3
	29	2.94	14		
	30	3.07	10		
Dec.	3			3.22	5
	10			2.52	4
	12	2.93	6	3.03	7
	13	2.87	6	3.12	5

The differences between the evening and morning values, as shown in table *A*, are not large, nor do they follow any very obvious law. It seems, however, worth the while to ascertain whether or not they indicate a correction to STRUVE's constant of aberration, or the value of the micrometer-screw employed.

Each of these quantities will furnish an equation of the form $ax + by = n$.

where x = a correction to the assumed value of the micrometer-screw.
y = a correction to the constant of aberration.
a = the mean of the difference of micrometer-readings for evening and morning, respectively.
b = mean difference of the coefficient of aberration for evening and morning.
n = the quantity P.M.—A.M. of table *A*.

Weights were assigned proportional to the number of determinations in the respective groups.

The thirteen equations, with the square roots of the weights, are as follows:

			″	$\sqrt{p}$
$+\ 5.37x$	$-1.17y$	$=$	-0.031	0.69
$+\ 7.01$	-1.14		$+\ .017$	.61
$+\ 5.61$	-1.11		$-\ .053$	.62
$+\ 2.11$	-1.03		$-\ .007$	.57
$-\ 4.66$	-1.06		$-\ .027$	.57
$-\ 3.87$	-0.98		$+\ .019$	.66
-12.02	-0.88		$-\ .087$	.72
$-\ 4.00$	-0.99		$+\ .010$	.71
$+\ 0.43$	-0.97		$+\ .026$	.78
$+\ 2.42$	-1.06		$+\ .102$	.76
$+\ 2.83$	-1.08		$-\ .050$	.71
$-\ 2.59$	-1.07		$-\ .004$	.71
$+\ 3.54$	-1.13		-0.099	0.35

Solving these equations in the usual way, we find

$$x = +''.00302 \pm ''.00183$$
$$y = +''.00465 \pm ''.00913$$

Resulting value of the constant of aberration.

$$20''.4497 \pm ''.0091$$

It may not be out of place to add that I hope very shortly to begin the work of re-observing this list of stars in a manner similar to that before employed, but with such improvements in the building and instrument as I hope will make possible a very appreciable advance in the accuracy of the results to be obtained.

Bethlehem, Pa., 1892 *Aug.* 29.

NEW VARIABLE OF SHORT PERIOD IN *VELA*.

$8^h\,33^m\,37^s$, $-46°\,55'.4$ 1875.0.

The following letter has been received from Prof. E. C. Pickering:

"Mr. A. W. Roberts, of Alice, South Africa, desires me to announce in the *Astronomical Journal* his discovery of a short-period variable in *Vela*. The star varies between the magnitudes 7.5 and 8.5 in a period of 4.6 days, increasing in brightness for 1.8 days, and decreasing for 2.8 days. The course of the variation is very regular.

"From a chart sent me by Mr. Roberts, I conclude that this variable star is identical with 8^h 2802 in the Cordoba Zone Catalogue, where the mean of the two positions for 1875.0 is $8^h\,33^m\,37^s.1$, $-46°\,55'\,26''$. On examining the photographs taken in Peru by officers of this observatory, I find five upon which the star occurs. Below are given the dates and Greenwich mean times of these photographs, with the corresponding magnitudes of the star:

Date	G.M.T.	Mag.
1889 Nov. 18	21.8	8.7
1890 Apr. 1	13.8	8.2
1890 May 2	14.0	9.6
1892 May 16	12.0	8.7
1892 May 17	12.2	9.3

"The scale of magnitudes is an arbitrary one. The photographic faintness of the star is probably due to its reddish color. Its variation appears to be confirmed by these photographs."

1892 *August* 25.

OBSERVATIONS OF μ *HERCULIS*.

By A. Hall.

Communicated by Capt. F. V. McNair, Superintendent.

Date	p °	s ″
1892.636	31.0	0.68
1892.644	33.0	0.89
1892.661	32.3	0.87
1892.663	30.0	0.90
1892.651	31.58	0.835

This faint and interesting pair has described nine-tenths of its apparent orbit since its discovery by Alvan Clark, in 1856.

Mr. Leuschner makes the period to be forty-five years.

ASTEROID 1892 *A*.

Under the arrangement announced on p. 55 (No. 271) of the Journal, the above notation has been assigned to an asteroid of the twelfth magnitude, discovered by Wolf at Heidelberg, and observed by Palisa at Vienna, with the following position:

1892 Aug. $26^d\,10^h\,52^m.0$ Vienna M.T. $\alpha = 22^h\,42^m\,16^s$, $\delta = -10°\,22'$. Daily motion, [illegible]

EPHEMERIS OF COMET *a* 1892 (*SWIFT*).

BY F. GERTRUDE WENTWORTH.

The following ephemeris was computed from the elements in the last number, page 72, which give the equatorial coordinates (1892.0),

$$x = (9.9229286)\, r \sin(349^\circ\ 3'\ 36''.4 + v)$$
$$y = (9.9997811)\, r \sin(257\ \ 52\ \ 20.5 + v)$$
$$z = (9.7381035)\, r \sin(345\ \ \ 5\ \ 25.8 + v)$$

Comparison with Prof. FRISBY's observation of Aug. 15, gives the deviations (O—C), —0s.3 in α, and —7″.6 in δ. This close adherence, after an interval of seven weeks from the date of the last observation on which the orbit was based, seems to furnish additional confirmation that the conic section does not sensibly differ from a parabola.

EPHEMERIS FOR GREENWICH MIDNIGHT.

Gr. M.T.	App. α	App. δ	log Δ	Br.
	h m s	° ′		
Sept. 22.5	0 14 5.0	+49 31.6	0.2883	0.060
23.5	12 50.7	49 18.5		
24.5	11 37.4	49 5.4		
25.5	10 25.2	48 51.3		
26.5	9 14.2	48 37.0	0.2938	0.056
27.5	0 8 4.3	+48 22.5		
Sept. 28.5	0 6 55.8	+48 7.8		
29.5	5 48.6	47 52.7		
30.5	4 43.0	47 37.4	0.3000	0.053
Oct. 1.5	3 38.9	47 21.8		
2.5	2 36.4	47 5.9		
3.5	1 35.5	46 49.8		
4.5	0 0 36.3	46 33.5	.3070	.050
5.5	23 59 38.9	46 17.1		
6.5	58 43.2	46 0.4		
7.5	57 49.3	45 43.6		
8.5	56 56.7	45 26.7	.3146	.046
9.5	56 5.2	45 9.6		
10.5	55 15.4	44 52.2		
11.5	54 27.0	44 34.7		
12.5	53 40.7	44 17.1	.3230	.043
13.5	52 56.3	43 59.5		
14.5	52 13.7	43 41.8		
15.5	51 32.8	43 24.0		
16.5	50 54.0	43 6.1	.3320	.040
17.5	50 17.0	42 48.2		
18.5	49 42.0	42 30.2		
19.5	49 9.0	42 12.2		
20.5	23 48 38.1	+41 54.7	0.3415	0.037

REAPPEARANCE OF 1953 *T AURIGAE.*

A cable dispatch received Sept. 2, announces the reappearance of this variable (the so-called *Nova*). It was observed as 9M.2 on Aug. 21, and 9M.3 on Aug. 31. Spectrum monochromatic.

COMET *d* 1892 (*BROOKS, August 28*).

A telescopic comet was discovered by BROOKS, on August 28. The following are all the observations that have come to hand.

M.T.		α	δ	Observer
d h m s		h m s	° ′ ″	
Aug. 31 13 55 10	Northfield	6 6 50.44	+31 40 38.9	Wilson
Sept. 1 13 5 12	Cambridge	9 1.66	31 35 51.2	Wendell
1 13 31 50	Northfield	9 15.83	31 35 19.0	Wilson
2 14 58 13	Cambridge	11 42.48	31 29 39.6	Wendell
4 0 15	Greenwich	14 41.70	31 22 50	Barnard
4 15 25 7	Northfield	6 16 56.70	+31 17 8.7	Wilson

The conditions make the determination of the orbit very indeterminate from these short intervals. A computation, however, indicates an earlier perihelion passage, a greater perihelion distance, and a smaller inclination, than the following elements by Dr. BERBERICH, received through the courtesy of Mr. RITCHIE, who obtained them by cable for the *Science Observer* circular.

Gr. M.T.
$T =$ 1892 Dec. 19.69
$\omega = 269^\circ\ 21'$
$\Omega = 261\ \ \ 3$
$i = \ \ 27\ \ 57$
$q = 0.6991$

EPHEMERIS FOR GR. MIDNIGHT.

1892	α	δ
	h m s	° ′
Sept. 13.5	6 39 32	+30 10
17.5	6 50 14	29 30
21.5	7 2 20	28 42
25.5	7 14 28	+27 44

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DISCOVERY AND OBSERVATIONS OF A FIFTH SATELLITE TO *JUPITER*.

By E. E. BARNARD.

Since July 1 of this year, I have had the use of the 36-inch refractor on one night each week. Previous to this I had no regular use of the instrument, and the observations made with it were of specified objects, the time being limited to the object. Among other things that I have devoted the instrument to on my nights, was a search for new objects. Several of the nights have been bad, and have more or less limited the investigations.

Nothing of special importance was encountered until the night of September 9, when, in carefully examining the immediate region of the planet *Jupiter*, I detected an exceedingly small star close to the planet and near the 3d satellite. I at once suspected this to be a new satellite. I at once measured the distance and position-angle of the object with reference to satellite III. I then tried to get measures referred to *Jupiter*, but found that one of the wires had got broken out and the other loosened. Before anything further could be done the object disappeared in the glare about *Jupiter*. Though I was positive the object was a new satellite, I had only the one set of measures, which was hardly proof enough for announcement.

I replaced the wires the next morning. The next night with the great telescope being Professor SCHAEBERLE'S, he very kindly gave the instrument up to me, and I had the pleasure of verifying the discovery, and secured a good set of measures at elongation. In these observations, and those of the succeeding night, only distances from the following limb of *Jupiter* could be measured. These were observed with the wires set perpendicular to the belts. The planet was thrown outside the field, the satellite bisected, and then the limb brought in and bisected also. This method would not permit any measures from the poles of the planet for latitude. On the 12th, I inserted a strip of mica, carefully smoked, in front of the field-lens, for occulting the planet. This served admirably, permitting the satellite and planet to be both seen at once, and measures from the polar limbs could be made with great ease. The observations of the satellite from the 12th were all thus made.

To avoid any personal equation, I have on each night measured the diameters of the planet, for use in reducing the observations to the center of *Jupiter*. Since the 12th, these have been measured through the smoked mica, so as to avoid introducing any error from the reduced brightness of the planet. The diameters were measured by the method of double distances.

Just what the magnitude of the satellite is, it is at present quite impossible to tell. Taking into consideration its position, however, in the glare of *Jupiter*, it would, perhaps, not be fainter than the thirteenth magnitude. It will only be possible to settle this question with any certainty by waiting until some small star of the same magnitude is seen close to *Jupiter*, and then after determining its magnitude when away from the planet. In general the satellite has been faint — much more difficult than the satellites of *Mars*. On the 13th inst., however, when the air was very calm, it was quite easy.

It is scarcely probable that this satellite will be seen with anything less than 26 inches, and only with that under first-class conditions.

I give here the observations that I have so far obtained, and defer any suggestions as to a name until a later period. It certainly should not disturb the present harmony existing in the Roman numerals already applied to the satellites. It is so wholly different from any of the other moons in physical aspect, that it ought, in a sense, to be considered as independent of them, and simply be called, say, the Fifth Satellite, with a suitable mythological name.

It will be seen that, on three of the dates of observation, the east elongation is well covered in the measures.

Plotting the observations at elongation, the following values of the distance were obtained:

					[illegible]
Sept. 10	apparent	61.04	log *R* =	7.08267	1122[illegible] [illegible]
12	"	61.55	"	7.08462	1127[illegible] [illegible]
14	"	61.60	"	7.08324	112[illegible] [illegible]

From these the following periods result, using the well-known formula:

$$P = p\sqrt{\frac{m}{M}\,\frac{R^3}{r^3}}$$

m being the mass of the earth, M that of *Jupiter*, and r and p the distance and period of our moon.

Sept. 10 the observations give period	=	11h 47.6m
12 " " " "	=	11 52.3
14 " " " "	=	11 49.0
Mean		11 49.63

The observations are all in the Standard Pacific time, (8 hours slow of Greenwich).

The value of the micrometer-screw used in these observations is 9″.901. No correction has been applied for refraction.

After the 11th inst., the micrometer was removed before or after the observations on each night. It was also removed on the morning of the 10th to replace the wires. This will account for the apparent changes of parallel.

1892 *September* 9.

Measures referred to Satellite III.

Direct Distance.

h m s	r	″
12 13 33	28.670	28.58
12 14 58	28.619	28.79

For Position-Angle.

h m s	°	P. A. °
12 19 31	125.0	295.8
12 21 28	125.1	295.9
12 31 40	129.7	300.5
12 33 43	131.1	301.9

Parallel = 279°.2

Direct Distance.

h m s	r	″
12 41 23	29.241	22.92
12 43 48	29.274	22.60
12 47 33	29.341	21.93

Coincidence of wires, 31r.556.

1892 *September* 10.

Measured equatorial diameter of *Jupiter* (by double distance), 48″.93.

The half-value of this has been added to the measures from the limb, to reduce the observation to the center of *Jupiter*.

For position-angle of belts:

Circle reading = 255°.8 (3 obs.) Position-angle = 67°.1.
Parallel = 278°.7 (2 obs.)

Coincidence of micrometer-wires, 29r.003.
New wires put in this morning.

Standard Pacific Time h m s	Micrometer readings r	Dist. from f. limb ″	Distance from center ″
11 45 20	26.250	27.25	51.72
11 47 30	26.183	27.91	52.37
11 49 0	26.097	28.77	53.24
11 52 0	26.073	29.00	53.46
11 52 25	25.065	29.08	53.54
11 5 25	25.745	32.55	57.01
12 7 20	25.631	33.38	57.84
12 14 28	25.686	32.84	57.30
12 20 30	25.419	35.18	59.94
12 23 10	25.494	34.74	59.20
12 26 10	25.413	35.54	60.00
12 32 30	25.408	35.60	60.06
12 35 30	25.384	35.83	60.29
12 39 35	25.395	35.73	60.19
12 41 30	25.330	36.37	60.83
12 45 10	25.366	36.01	60.17
12 48 10	25.345	36.22	60.68
12 50 30	25.198	37.68	62.14 *
12 54 10	25.349	36.48	60.94
13 1 40	25.281	36.83	61.29
13 4 0	25.370	35.97	60.43
13 6 25	25.475	34.93	59.39
13 9 23	25.427	35.41	59.87
13 11 5	25.421	35.47	59.93
13 19 20	25.502	34.67	59.13
13 22 43	25.534	34.35	58.81
13 23 47	25.657	33.13	57.59
13 25 15	25.660	33.10	57.56
13 27 35	25.707	32.64	57.10
13 29 45	25.699	32.72	57.18
13 34 5	25.712	32.59	57.05
13 34 22	25.891	30.81	55.27
13 35 57	25.903	30.70	55.16
13 37 33	25.857	31.15	55.61
13 38 43	25.896	30.76	55.22
13 40 25	25.920	30.53	54.99
13 42 37	25.950	30.23	54.69
13 46 4	26.099	28.76	53.22
13 47 40	26.031	29.43	53.89
13 51 35	26.234	27.42	51.88
13 54 51	26.275	27.01	51.47
13 57 41	26.434	25.34	49.80
13 59 7	26.451	25.27	49.73
14 1 5	26.490	24.88	49.34
14 5 0	26.676	23.04	47.50
14 7 54	26.834	21.51	45.97
14 11 0	26.885	20.97	45.44

* Reject.

1892 *September* 11.

For position-angle belts:

Circle-reading = 255°.4. Position-angle = 66°.7.
Parallel = 278°.7 (2 obs.)

Coincidence of wires = 28r.998.

Measured equatorial diameter of *Jupiter*, 49″.11.

Standard Pacific Time	Micrometer readings	Dist. from f. limb	Distance from center
h m s	r	″	″
12 27 2	25.359	36.03	60.58
12 35 12	25.346	36.16	60.71
12 38 17	25.265	36.96	61.51
12 41 35	25.230	37.31	61.86
12 44 6	25.262	36.99	61.51
12 46 37	25.385	35.78	60.33
12 48 11	25.286	36.76	61.31
12 52 32	25.429	35.25	59.80
12 54 17	25.373	35.89	60.44
12 56 4	25.393	35.70	60.25
13 0 7	25.432	35.22	59.77
13 1 28	25.447	35.16	59.71
13 3 2	25.477	34.86	59.41
13 4 30	25.515	34.49	59.04
13 7 49	25.595	33.70	58.25
13 9 24	25.551	33.11	57.69
13 10 57	25.517	34.17	58.72
13 13 43	25.535	34.29	58.84
13 15 14	25.540	34.24	58.79
13 17 42	25.555	34.09	58.64

1892 *September* 12.

Observed polar diameter, 46″.01.

The half-value of this has been used in deducing the apparent Jovicentric latitudes.

Measured equatorial diameter of *Jupiter*, 48″.97.

Position-angle of the belts:

Circle-reading = 255°.4 (5 obs.) Position-angle = 66°.7

Parallel = 278°.7

Coincidence of wires = 29r.000.

Standard Pacific Time	Circle readings	Dist. from f. limb	Distance from center
h m s	r	″	″
12 3 1	32.509	34.75	59.23
12 4 56	32.395	33.62	58.10
12 6 20	32.393	33.60	57.08
12 7 27	32.504	34.70	59.18
12 9 22	32.562	35.18	59.66
12 11 0	32.612	35.77	60.25
12 12 14	32.568	35.24	59.72
12 13 53	32.629	35.93	60.41
12 16 11	32.625	35.89	60.37
12 17 56	32.723	36.86	61.34
12 19 16	32.550	35.15	59.63
12 20 16	32.641	36.05	60.53
12 22 8	32.639	36.03	60.51
12 23 12	32.730	36.93	61.41
12 24 3	32.685	36.49	60.97
12 25 7	32.694	36.58	61.06
12 26 31	32.740	37.03	61.51
12 28 54	32.687	36.51	60.99
12 30 16	32.718	36.82	61.30
12 31 40	32.747	37.10	61.58
12 32 46	32.750	37.13	61.61
12 34 23	32.752	37.15	61.63
12 36 11	32.683	36.47	60.95
12 37 50	32.783	37.46	61.94

Standard Pacific Time	Circle readings	Dist. from f. limb	Distance from center
h m s	r	″	″
12 39 16	32.725	36.88	61.36
12 40 53	32.769	37.32	61.80
12 42 31	32.731	36.94	61.42
12 43 44	32.773	37.36	61.84
12 45 19	32.660	36.24	60.72
12 48 33	32.707	36.71	61.19
12 49 48	32.730	36.94	61.42
12 51 1	32.647	36.11	60.59
12 52 14	32.642	36.06	60.54
12 54 18	32.660	36.24	60.72
12 56 1	32.659	36.23	60.71
12 58 23	32.583	35.48	59.96
13 2 4	32.525	34.90	59.38
13 3 43	32.529	35.04	59.52
13 4 56	32.605	35.70	60.18
13 6 6	32.480	34.46	58.94
13 7 41	32.506	34.72	59.52
13 9 6	32.542	35.07	59.55
13 10 29	32.412	33.79	58.27
13 11 56	32.404	33.71	58.19
13 13 21	32.348	33.15	57.63
13 14 57	32.363	33.30	57.78
13 17 27	32.303	32.71	57.19
13 20 6	32.284	32.49	56.97

From North Pole.

Stand. Pac. Time	Circle read'g		♃ =
h m s	r		
11 43 31	26.775	22.03	+0.97
11 46 48	26.765	22.13	+0.87
11 49 28	26.773	22.05	+0.95
11 50 58	31.262	22.40	+0.60

From South Pole.

11 53 16	26.595	23.81	+0.81
11 54 23	26.634	23.43	+0.43
11 55 33	26.620	23.57	+0.57
11 56 28	26.574	24.01	+1.01

From North Pole.

13 31 3	31.554	25.29	−2.29
13 32 21	31.619	25.93	−2.93
13 33 26	31.533	26.08	−3.08
13 34 31	31.579	26.54	−3.54
13 35 46	31.506	24.81	−1.81
13 37 56	31.657	26.31	−3.31
13 39 26	31.511	24.89	−1.89

From South Pole.

13 41 48	26.910	20.73	2.27
13 43 31	26.969	20.11	2.89
13 44 41	26.931	20.49	2.51
13 45 12	26.931	20.49	2.51
13 45 36	26.899	20.80	2.20
13 46 4	26.883	20.35	2.65
13 46 52	26.908	20.71	2.29
13 47 11	26.960	20.20	2.80
13 48 12	26.943	20.37	2.63
13 48 49	26.918	20.62	2.38
13 49 17	26.920	20.60	−2.40
13 51 22	26.919	20.61	−2.39
13 54 36	26.895	20.84	−2.16

1892 *September* 13.

For position-angle of belts:

Circle-reading = 257°.(1 obs.) Position-angle = 67°.4.
Parallel = 279°.8.

Measured polar diameter, 46″.10.
Coincidence of wires, — $28^{\mathrm{r}}.995$.

1892 *September* 13.

From South Pole.

Stand. Pac. Time	Circle-read'g		♃ 3
h m s	r	″	″
12 9 38	26.637	23.35	+0.30
12 10 19	26.625	23.17	+0.42
12 12 31	26.609	23.03	+0.58
12 18 34	26.633	23.39	+0.34
12 20 7	26.634	23.38	+0.33

From North Pole.

12 23 22	31.307	22.89	+0.16
12 26 17	31.324	23.03	+0.02
12 29 8	31.479	24.60	—1.55*
12 31 12	31.356	23.38	—0.33
12 35 17	31.394	23.75	—0.70
12 36 48	31.297	22.79	+0.26

* Wind shaking telescope badly. Reject.

From South Pole.

12 53 32	26.780	21.93	—1.12
12 54 2	26.707	22.66	—0.39
12 55 9	26.745	22.28	—0.77
12 55 37	26.779	21.91	—1.11
12 56 40	26.721	22.52	—0.53
12 57 24	26.661	23.11	+0.06

From North Pole.

13 2 6	31.324	23.06	—0.01
13 3 17	31.412	23.93	—0.83
13 4 17	31.474	24.55	—1.50
13 4 51	31.399	23.80	—0.75
13 6 0	31.125	24.06	—1.01
13 7 15	31.308	22.90	+0.16

Very high wind. Telescope shaking. No measures of distance possible.

1892 *September* 14.

Position-angle of belts:

Circle-reading = 256°.7 (3 obs.) Position-angle = 67°.0.
Parallel = 279°.7 (3 obs.)

Measured polar diameter, 45″.95.
Measured equatorial diameter, 49″.18.
Coincidence of wires = $29^{\mathrm{r}}.007$.

Standard Pacific Time	Circle readings	Dist. from f. limb	Distance from center
h m s	r	″	″
11 48 28	25.638	33.36	57.95
11 50 5	25.589	33.85	58.44
11 53 0	25.565	34.08	58.67
11 54 2	25.564	34.12	58.74
11 55 45	25.419	35.23	59.82
11 57 16	25.422	35.50	60.09
12 0 3	25.460	35.12	59.74
12 2 36	25.391	35.84	60.40
12 3 30	25.420	35.52	60.44
12 4 30	25.384	35.87	60.46
12 6 55	25.334	36.40	60.99
12 8 5	25.294	36.77	61.36
12 10 10	25.339	36.32	60.94
12 12 0	25.361	36.10	60.69
12 14 5	25.318	36.53	61.12
12 15 22	25.308	36.63	61.22
12 16 20	25.293	36.78	61.37
12 17 27	25.299	36.72	61.34
12 18 48	25.260	37.01	61.60
12 19 52	25.209	37.61	62.20
12 20 45	25.305	36.66	61.25
12 21 37	25.285	36.86	61.45
12 23 12	25.261	37.09	61.68
12 24 8	25.253	37.17	61.76
12 25 15	25.269	37.01	61.60
12 26 25	25.313	36.58	61.17
12 27 35	25.282	36.88	61.47
12 28 30	25.222	37.48	62.07
12 29 25	25.295	36.76	61.35
12 30 25	25.329	36.42	61.01
12 31 25	25.282	36.88	61.47
12 32 35	25.275	36.95	61.54
12 36 15	25.240	37.30	61.89
12 39 25	25.395	35.77	60.36
12 40 25	25.273	36.97	61.56
12 41 37	25.343	36.28	60.87
12 44 15	25.468	35.04	59.63
12 45 45	25.380	35.91	60.50
12 47 12	25.459	35.15	59.74
12 48 25	25.418	35.54	60.13
12 49 28	25.439	35.24	59.83
12 50 20	25.426	35.46	60.05
12 51 50	25.390	35.82	60.41
12 52 45	25.426	35.46	60.05
12 54 5	25.519	34.54	59.13
12 54 55	25.487	34.86	59.45
12 56 15	25.558	34.15	58.74
12 56 50	25.531	34.42	59.01
13 0 10	25.624	33.50	58.09
13 1 45	25.571	34.02	58.61

From North Pole.

Stand. Pac. Time	Circle-read'g		♃ 3
h m s	r	″	″
11 1 30	31.155	21.27	+1.70
11 3 37	31.139	21.11	+1.86
11 4 45	31.145	21.17	+1.80
11 6 17	31.094	20.67	+2.30
11 7 6	31.108	20.80	+2.17

From South Pole.

Stand. Pac. Time	Circle-read'g		Δ
h m s	r	"	"
11 8 18	26.379	26.02	+3.05
11 9 12	26.481	25.01	+2.04
11 10 25	26.453	25.25	+2.28
11 11 25	26.475	25.07	+2.10
11 13 50	26.479	25.03	+2.06

From North Pole.

13 16 45	31.471	24.40	−1.43
13 18 18	31.483	24.52	−1.55
13 19 20	31.475	24.44	−1.47
13 20 15	31.523	24.91	−1.94
13 21 10	31.465	24.34	−1.37

From South Pole.

13 22 15	26.850	24.36	−1.61
13 23 42	26.790	24.89	−1.08
13 24 30	26.830	24.56	−1.11
13 25 30	26.890	20.96	−2.01
13 26 12	26.824	24.62	−1.35

From North Pole.

13 38 20	31.492	24.61	−1.64
13 39 20	31.536	25.04	−2.07
13 40 20	31.529	24.97	−2.00
13 41 40	31.529	24.97	−2.00
13 42 32	31.533	25.01	−2.04

From South Pole.

13 44 20	26.883	21.03	−1.94
13 45 25	26.895	20.91	−2.10
13 46 15	26.949	20.38	−2.59
13 47 5	26.884	21.02	−1.95
13 47 55	26.832	21.54	−1.43

From North Pole.

13 59 50	31.583	25.51	−2.54
14 0 50	31.641	26.08	−3.11
14 2 7	31.545	25.13	−2.16

From South Pole.

14 3 7	26.912	20.76	−2.21
14 4 2	26.895	20.91	−2.06
14 4 59	26.940	20.47	−2.50

1892 *September* 16.

Sky thick and the satellite extremely difficult throughout the observations.

From North Pole.

Stand. Pac. Time	Circle-reading		Δ
h m s	r	"	"
11 16 35	31.192	[illegible]	[illegible]
11 18 17	31.159	21.32	+1.96
11 19 57	31.101	20.74	+2.54
11 21 20	31.156	21.29	+1.99

From South Pole.

11 25 57	26.150	25.31	+2.00
11 27 42	26.568	24.14	+0.86
11 29 27	26.620	23.23	−0.05*
11 32 17	26.535	24.37	+1.09
11 35 55	26.564	24.47	+1.29

* Reject.

Coincidence of wires = 29r.006.

In all the measures from the polar limbs, the wires were carefully adjusted parallel to the belts of *Jupiter*, and the Δ's are simply the differences between the polar [illegible] and the measured polar semi-diameters.

In the equatorial distances, the wires were [illegible] placed perpendicular to the belts (by the position circle), and the final distances from the center are the measured distances from the *following* limb plus the measured equatorial semi-diameter.

Standard Pacific Time	Circle reading	Dist. from f. limb	Dist. fr. center
h m s	r	"	"
11 49 32	25.473	34.98	59.97
11 53 12	25.370	36.00	60.99
11 55 37	25.479	34.92	59.91
11 56 47	25.410	35.61	60.60
12 7 2	25.255	37.14	62.13
12 9 47	25.326	36.44	61.43
12 11 37	25.280	36.89	61.87
12 14 21	25.292	36.78	61.77
12 16 0	25.268	37.01	62.00
12 17 37	25.221	37.48	62.47
12 20 29	25.175	37.93	62.92
12 28 33	25.240	37.29	62.28

Satellite lost here in the thickening sky.

The latitude-measures of the satellite show that [illegible] lies in the plane of *Jupiter's* equator, and consequently [illegible] the satellite is a very old member of *Jupiter's* family, since it would doubtless take ages for the orbit to be so [illegible]

Mt. Hamilton, 1892 *September* 17.

OCCULTATION OF *MARS*.

By E. FRISBY.

I observed the first and second contacts of the occultation of *Mars* on Sept. 3. The moon was too low to [illegible] and fourth contacts, being obscured by a tree near the horizon.

	1st Contact	2d Contact
Washington M.T.	13h 10m 1[illegible].1	13h 20m 53.6

ELEMENTS AND EPHEMERIS OF COMET *d* 1892 (*BROOKS*),

BY REV. G. M. SEARLE.

I have computed the following elements of this comet from the observations by WENDELL on Sept. 1, and one of my own on Sept. 16, using the ratio of the distances resulting from BERBERICH's orbit. BARNARD's observation of Sept. 1, using either the time of the *Science Observer* circular, or that of the *Astronomical Journal*, does not seem to be very well represented, being about 1′ in error; but an observation made by me on Sept. 23 gives residuals of only —9″ and +32″. It seems hardly worth while at present to attempt any further approximation.

$$T = \text{Dec. } 28.0870 \text{ Gr. M.T.}$$

$$\left.\begin{aligned}\omega &= 252^\circ\ 21'\ 48''\\ \Omega &= 264\ \ 29\ \ 18\\ i &= \ \ 21\ \ 47\ \ 32\end{aligned}\right\}\ 1892.0$$

$$\log q = 9.991557$$

The perihelion distance is as yet quite uncertain. The following are the coordinate formulas.

$$x = [9.958435]\, r \sin(v + 216^\circ\ 20'\ 46'')$$
$$y = [9.975859]\, r \sin(v + 147\ \ 17\ \ \ 2)$$
$$z = [9.723137]\, r \sin(v + 203\ \ 52\ \ 18)$$

EPHEMERIS FOR GREENWICH MIDNIGHT.

Gr. M.T.	App. α	App. δ	log Δ	Br.
	h m s	° ′		
Oct. 4.5	7 39 21	+25 21.6		
5.5	42 27	25 5.2	0.1862	3.50
6.5	45 35	24 45.2		
7.5	48 41	24 21.6	.1752	
8.5	51 54	24 3.3		
9.5	7 55 6	+23 41.2	0.1641	4.10

OBSERVATIONS OF COMET *d* 1892 (*BROOKS, August 28*),

MADE AT THE GOODSELL OBSERVATORY OF CARLETON COLLEGE, NORTHFIELD, MINN., WITH THE 16-INCH EQUATORIAL AND FILAR-MICROMETER,

BY H. C. WILSON,

[Communicated by the Director, WM. W. PAYNE.]

1892 Northfield M.T.	✳	No. Comp.	☄ — ✳ Δα	☄ — ✳ Δδ	☄'s apparent α	☄'s apparent δ	log *p*Δ for α	log *p*Δ for δ
d h m s			m s	′ ″	h m s	° ′ ″		
Aug. 31 13 55 10	1	9 , 4	+0 50.27	+0 27.1	6 06 50.41	+31 40 38.9	*n*9.694	0.680
Sept. 1 13 34 50	1	9 , 4	+3 15.79	—4 54.1	6 09 16.00	+31 35 17.7	*n*9.694	0.704
1 13 34 50	2	9 , 1	+1 26.19	—6 52.7	6 09 15.82	+31 35 18.3	*n*9.694	0.704
1 13 34 50	3	9 , 4	—0 19.90	+0 11.0	6 09 15.67	+31 35 21.0	*n*9.694	0.704
4 15 25 7	4	9 , 4	+2 55.31	—5 25.7	6 16 56.70	+31 17 08.7	*n*9.622	0.548
4 15 25 7	5	9 , 4	—0 10.93	+0 19.5	. . . .	. . . .	*n*9.622	0.548

Mean Places for 1892.0 of Comparison-Stars.

✳	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	6 05 58.96	(+1.21) (+1.25)	+31 40 07.1	(+4.4) (+4.4)	Leyden A.G. Zones 397. 121
2	6 07 48.39	+1.24	+31 12 06.8	+4.4	Leyden A.G. Zones 399. 83
3	6 09 31.36	+1.23	+31 35 05.6	+4.4	Leyden A.G. Zones 368, 22
4	6 14 00.07	+1.32	+31 22 30.0	+4.4	Leyden A.G. Zones 276. 3
5	6 17 06	+1.30	+31 16.8	+4.4	Anonymous, 9M

REMARKS.

Sept. 1. The comet is barely visible in the 5-inch finder; easily observed in the 16-inch. Nucleus pretty well defined; head 1′ in diameter; tail 3′ in length.

Sept. 4. Comet faint at first in moonlight, but easily seen during all the measures. Nucleus about 11M.

OBSERVATIONS OF COMET *a* 1892 (SWIFT).

MADE AT THE U. S. NAVAL OBSERVATORY.

BY PROF. E. FRISBY.

[Communicated by the Superintendent.]

1892 Washington M.T.	✱	No. Comp.	☄ — ✱ Δα	☄ — ✱ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
d h m s			m s	′ ″	h m s	° ′ ″		
July 16 10 56 2.0	1	17 , 1	+2 16.80	−0 8.4	0 59 59.74	+49 43 17.5	n9.750	0.611
23 10 6 16.4	2	20 , 1	+1 2.01	−3 17.0	1 3 7.64	+50 49 11.7	n9.853	0.665
Aug. 2 12 9 57.4	3	20 , 1	+2 15.22	−0 31.4	1 3 51.22	+52 3 19.2	n9.816	9.888
12 11 34 53.9	4	16 , 1	−0 39.16	−6 13.3	1 0 6.88	+52 49 0.8	n9.816	9.823
15 11 25 51.6	4	15 , 3	−2 35.95	+1 28.3	0 58 10.30	+52 56 43.2	n9.882	9.620

Mean Places for 1892.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 57 11.98	+0.96	+49 44 1.6	−6.0	Oe. Arg. N. 1025
2	1 2 4.31	+1.26	+50 53 5.4	−3.7	Bonn VI. +50° 222
3	1 1 34.35	+1.65	+52 3 52.1	−1.8	Oe. Arg. N. 1114
4	1 0 44.10	{+1.94 +2.15}	+52 55 43.5	{−1.4 −1.4}	Radcliffe 328

FILAR-MICROMETER OBSERVATIONS OF WOLF'S PERIODIC COMET.

(*1884 III = 1891 II*.)

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY.

BY E. E. BARNARD.

Continued from *A. J.* XI, page 13.

1891 Mt.Hamilton M.T.	✱	No. Comp.	☄ — ✱ Δα	☄ — ✱ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
d h m s			m s	′ ″	h m s	° ′ ″		
May 7 11 56 2	3	12 , 4	−0 55.84	−1 34.4	22 41 56.26	+14 7 50.4	n9.659	0.663
14 15 9 17	4	22 , 5	−0 40.89	−4 43.2	22 57 23.42	+15 47 28.2	n9.641	0.640
June 3 14 12 57	5	3 , 6*	+0 6.21	+0 32.6	23 43 13.92	+20 21 48.8	n9.645	0.590
July 4 13 57 55	6	18 , 4	+0 45.26	+7 33.4	1 0 34.08	+26 17 9.3	n9.243	0.428
6 13 36 43	7	9	+0 15.86	+0 6.0	1 5 46.69	+26 33 46.1	n9.685	0.554
11 14 41 56	8	18 , 4	−0 4.37	−0 39.4	1 19 12.1	+27 11.2	n9.594	0.433
12 14 11 8	9	12 , 4	−0 10.05	−4 43.0	1 21 49.5	+27 17.8	n9.607	0.426
13 13 34 58	10	12 , 4	−1 5.46	−0 21.1	1 24 24.3	+27 28.8	n9.681	0.528
29 13 20 46	11	12 , 4	+0 37.28	+3 24.2	2 7 37.35	+28 24 27.1	9.681	0.508
Aug. 1 11 38 47	12	18 , 4	+0 11.31	+0 53.1	2 16 8.42	+28 25 55.0	n9.682	0.510
9 12 27 6	13	3 , 4*	−0 31.69	−0 21.1	2 37 15.0	+28 10.5	n9.714	0.587
11 11 48 41	14	12 , 4	+0 27.03	+6 50.9	2 42 26.0	+28 3.8	n9.72[illegible]	[illegible]
14 13 6 6	15	12 , 4	+0 58.08	−1 20.6	2 50 21.37	+27 17 50.2	n9.674	0.505
28 11 30 30	16	1 , 4*	−0 1.16	−0 19.3	. . . .	. . . . . .	n9.678	0.563
31 12 36 32	17	10 , 4	−0 7.19	+5 34.8	2 32 28.01	+21 55 58.5	9.667	0.546
Sept. 3 11 24 35	18	18 , 4	−0 20.82	+2 21.3	3 39 6.43	+21 15 18.5	9.701	0.618
3 16 9 48	18	8 , 4*	+0 3.56	−0 43.9	3 39 30.81	+21 12 13.3	8.914	9.367
27 13 7 42	19	10 , 4	+0 9.72	−9 6.7	4 22 37.60	+15 28 52.1	9.511	0.574
30 11 49 59	20	12 , 4	+2 20.97	+1 15.6	4 26 22.97	+14 5 36.7	n9.618	[illegible]
Oct. 8 13 21 40	21	12 , 4	−0 13.00	+2 18.0	4 34 27.0	+10 3.0	9.784	[illegible]
Nov. 2 10 36 47	22	12 , 4	−0 23.99	−7 44.2	4 40 35.18	−5 16 33.5	9.579	[illegible]
21 10 49 5	23	3 , 4*	+0 3.17	+2 8.3	4 28 40.58	−11 12 24.6	9.246	0.847
27 10 3 16	24	2 , 4*	0 26.91	3 12.8	4 26 41.68	12 56 15.9	[illegible]	0.815
Dec. 17 7 32 0	25	12 , 4	+1 19.92	+0 9.4	4 16 15.65	−11 50 56.4	[illegible]	0.809
17 10 34 6	26	2 , 4*	−0 31.13	−4 2.2	4 16 12.70	−11 51 1.1	[illegible]	0.813
21 6 39 17	25	3 , 4*	+0 16.27	+1 36.5	4 15 11.91	−11 49 29.9	9.521	0.795
21 8 49 21	25	3 , 4*	−0 11.16	+7 43.7	4 14 39.41	−11 13 23.2	9.332	0.850

* Δα measured with the micrometer

Mean Places for 1891.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
3	22 12 52.70	−0.60	+14 12 35.4	−10.6	W.B. XXII, 861
4	22 57 34.38	−0.37	+15 52 21.3	− 9.9	W.B. XXII, 1168
5	23 43 7.75	−0.04	+20 24 27.0	−10.8	B.B. +20 5353
6	1 0 18.31	+0.51	+26 9 38.1	− 2.2	W.B. O, 1470
7	1 5 30.39	+0.54	+26 33 44.9	− 1.8	W.B. I, 44
8	1 19 15.9	+0.62	+27 44.8	− 0.9	DM. +27 226
9	1 21 58.9	+0.65	+27 22.5	− 0.6	DM. +27 233
10	1 25 29.1	+0.69	+27 29.1	− 0.2	
11	2 6 59.07	+1.00	+28 21 1.0	+ 2.2	W.B. II, 2493
12	2 15 56.07	+1.04	+28 24 59.2	+ 2.7	B.B. +28
13	2 37 15.5	+1.18	+28 10.7	+ 1.5	DM. +28 454
14	2 44 57.8	+1.22	+27 56.9	+ 4.4	DM. +27 428
15	2 49 25.03	+1.26	+27 49 5.8	+ 5.0	L. 5378
16	. . . .	+1.57	. . . .	. . . . .	
17	2 32 33.58	+1.62	+24 50 45.9	+ 7.8	B.B. +24°526
18	3 39 24.78	+2.17	+24 12 48.8	+ 8.4	Elkin 22 = 21 *k Asterope*
19	4 22 25.72	+2.16	+15 37 44.8	+14.0	78 θ_2 Tauri = Rad.₂ 505
20	4 23 59.78	+2.22	+14 4 6.5	+14.6	W.B. IV, 453
21	4 54 37.7	+2.33	+10 0.0	+13.5	DM. +9 625
22	4 40 56.43	+2.74	− 3 9 4.3	+15.0	Schjellerup 1529
23	4 28 34.33	+3.08	−14 54 16.0	+13.4	W.B. IV, 573
24	4 27 5.44	+3.14	−12 32 45.0	+14.9	W.B. IV, 532
25	4 44 52.50	+3.23 +3.15 +3.08	−14 54 14.7	+ 8.9 + 8.3 + 7.8	Arg. Oe. 2984
26	4 16 10.90	+3.23	−14 47 10.8	+ 8.9	W.B. IV, 305

NEW ASTEROIDS.

Dr. H. Kreutz communicates to the Journal the following facts with reference to newly discovered asteroids.

Asteroid 1892 *A* (see p. 79, no. 271) was photographically discovered by Wolf on Aug. 22. The following is an ephemeris from a circular orbit computed by A. Berberich.

Berlin Midnight.

		α	δ
	d	h m s	° ′
1892 Oct.	2	22 12 25	−11 43.3
	6	15 52	44.7
	10	14 49	44.3
	14	22 14 1	−11 42.1

The ephemeris agrees well with a Vienna observation of Sept. 14.

A photographic plate by Dr. M. Wolf, of Sept. 1, shows the following two unknown asteroids.

1892 *B*	Sept. 1.	$\alpha = 23^h\ 44^m.7$,	$\delta = -3°\ 0'$;	12^M
1892 *C*	Sept. 1.	$\alpha = 23\ 55.4$,	$\delta = -4\ 14$;	11

1892 *B*, according to Berberich, is identical with (163) *Erigone*, and on this assumption he has calculated the following ephemeris.

Berlin Midnight.

		α	δ
	d	h m s	° ′
1892 Sept.	29	23 20 42	−6 39.7
Oct.	3	17 44	7 6.4
	7	14 59	7 30.2
	11	23 12 37	−7 54.1

Dr. Bidschof, at Vienna, thought he saw the asteroid in the ephemeris-place Sept. 14. Later, on Sept. 13, it was observed there, and also at Heidelberg, and the identity with (163) is thus made certain. The correction to the ephemeris is +10ˢ in α.

1892 *C*, which in any case is new, was later observed again, photographically, at Heidelberg, as follows:

Sept. $13^d\ 9^h\ 22^m.5$ Gr., $\alpha = 23^h\ 46^m.4$, $\delta = -5°\ 50'$;
Daily motion, -48^s in α, southward 8′.

CONTENTS.

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NOTE ON THE ELEMENTS OF SOME OF THE MORE RECENTLY DISCOVERED VARIABLES,

BY PAUL S. YENDELL.

7754 *W Cygni.*

During the season of 1891, I observed this star sixty-five times, from July 5 to Dec. 28. These observations indicate two minima, and one maximum, as follows:

Minima 1891 July 12 and Dec. 2; maximum, Sept. 19.

My observations of this year, beginning May 28, indicate a maximum on June 6, and a minimum on August 11.

Upon comparing these dates with those indicated by CHANDLER's elements, a very marked discordance appeared, the maxima occurring near the computed times of minimum, and *vice versa*.

Collecting all the dates of observed maxima and minima accessible to me, including those deduced from the original observations of Mr. GORE, kindly transmitted by him in manuscript for the purpose of this discussion, as were also the dates of Mr. SAWYER's observed maxima and minima, I find a complete series, excepting Ep. 1, of maxima, and one of the minima nearly as full, there being thirty-one of the former, and twenty-four of the latter.

These dates, with the residuals found by comparison with CHANDLER's elements, appear in the subjoined table. In the column headed Ob., S stands for SAWYER, G. for GORE, and Y. for myself. The residuals found as above are in the column O—C.

MAXIMA.

E	Date	w	Ob.	O—C′	O—C
				d	d
0	1885 Jan. 5	1	G	+23.0	+36.7
2	Aug. 26	1	G	+ 1.0	+ 7.1
2	Aug. 20	1	S	— 2.0	+ 1.1
3	Dec. 15	1	G	—11.0	—12.7
3	Dec. 16	½	S	—10.0	—11.7
4	86 May 18	1	G	+17.0	+10.5
4	May 14	½	S	+13.0	+ 6.5
5	Sept. 12	1	G	+ 8.0	— 3.3
5	Sept. 10	1	S	+ 6.0	5.3
6	87 Jan. 31	½	G	+23.0	+ 6.9
7	June 15	½	G	+32.0	+11.1
8	Sept. 11	½	G	— 3.0	—28.7
8	Sept. 13	1	S	— 4.0	29.7
9	88 Jan. 29	1	G	+ 8.0	—22.5
9	Jan. 29	1	S	+ 8.0	—22.5
10	June 5	½	S	+10.0	—25.3
11	Nov. 30	1	G	+62.0	+21.9
11	Nov. 12	½	S	+14.0	+ 3.9
12	89 Mar. 11	½	S	+37.0	— 7.9
13	Aug. 11	1	G	+64.0	+14.3
13	Aug. 22	½	S	+75.0	+25.3
14	Nov. 14	½	S	+33.0	—21.5
15	90 Apr. 28	½	S	+72.0	+12.7
16	Aug. 20	1	S	+66.0	— 4.1
17	91 Jan. 7	1	S	+74.0	+ 5.1
18	May 15	½	S	+76.0	+ 2.3
19	Sept. 15	1	S	+73.0	— 5.5
19	Sept. 19	1	Y	+77.0	— 1.5
20	1892 Jan. 28	1	S	+81.0	— 1.3
21	June 2	1	S	+82.0	— 6.1
21	June 6	½	Y	+86.0	— 2.1

MINIMA.

E.	Date	w	Ob.	O—C′	O—C
2	1885 June 10	1	G	—11.0	+ 3.0
3	Oct. 22	1	G	— 3.0	+ 6.2
3	Oct. 30	1	S	+ 5.0	+14.2
4	86 Feb. 15	1	G	—13.0	— 8.6
5	July 19	1	G	+15.0	+14.6
5	July 8	1	S	+ 4.0	+ 3.6
6	Nov. 10	1	G	+ 3.0	— 2.2
6	Nov. 5	1	S	— 2.0	7.2
8	87 July 23	1	S	+ 6.0	8.8
9	Dec. 8	1	S	+18.0	— 1.6
9	Dec. 17	1	G	+27.0	+ 7.4
11	88 Aug. 24	½	S	+26.0	— 3.2
12	89 Jan. 1	½	S	+30.0	1.0
13	May 29	½	S	+52.0	+13.2
14	Oct. 9	½	S	+39.0	+15.4
15	90 Jan. 29	1	S	+17.0	— 3.4
16	July 2	1	S	+73.0	+19.8
17	Nov. 10	1	S	+78.0	+20.0
19	91 July 12	1	Y	+70.0	+ 2.4
19	July 20	1	S	+78.0	+10.4
20	Dec. 2	½	Y	+87.0	+14.6
20	Dec. 8	1	S	+93.0	+20.6
22	1892 Aug. 11	1	Y	+88.0	+ 6.0
22	Aug. 12	1	S	+89.0	+ 7.0

A discussion of the residuals in the column O—C gives the following corrections:

	From Maxima	From Minima
	d	d
To the Epoch,	—12.7	—23.6
To the Period,	+ 1.5	+ 5.2

Using the weighted mean of the indicated corrections to the period, we have as elements,

Min. 1881 Sept. 18.1; Max. 1881 Nov. 30.3 + 130^d.8 *E*,

which appear to be the best at present attainable. The comparison with the observed times appears in the column O—C″ of the above table.

5758 *X Herculis.*

The variability of this star was announced by Gore in the *Astronomische Nachrichten*, No. 2981. I began observations upon it in the autumn of 1889, and have since kept it as constantly under observation as possible, obtaining five maxima and four minima. From the published observations of Col. Markwick, I have deduced one maximum and two minima. These are all the data at present available, and are given in the subjoined table. I have re-reduced all my own observations, so that some of the dates differ slightly from those already published.

Maxima.

E	Date	Ob.	O—C
			d
0	1890 June 22.7	Yendell	—6.66
1	Oct. 8.2	Yendell	+6.34
1	1891 July 17.0	Yendell	+4.64
4	July 15.0	Markwick	+2.64
7	1892 Apr. 13.0	Yendell	—8.86
8	July 21.0	Yendell	—0.36

Minima.

E	Date	Ob.	O—C
			d
0	1890 May 7.0	Yendell	+ 5.87
1	Aug 12.5	Yendell	+ 8.87
4	1891 May 21.0	Yendell	+ 6.87
4	May 1.0	Markwick	—10.13
6	1891 Nov. 25.0	Markwick	+ 5.87
8	1892 May 21.0	Yendell	— 5.13

Dorchester, Mass., 1892 *Sept.* 10.

From these data I obtain the following elements, which appear to be the best at present attainable:

Min. 1890 May 1.13; Max. 1890 June 22.7 + 94^d.5 *E*

which give the residuals in column O—C.

906 *R Trianguli.*

Since publishing in this Journal (p. 11 of the current volume) my confirmation of the variability of this star, I have received a letter from Mr. George Knott, giving two minima and a maximum from his own observations, as follows:

Minima, 1891 Feb. 22, Mag. 11^M.7; 1891 Nov. 8, Mag. 11^M.7.
Maximum, 1892 Mar. 12, Mag. 5^M.9.

The accordance of the observed maximum with my published date for the same, is very satisfactory, both in date and magnitude.

Mr. Knott states that his observations point to a period of about 260 days; this, as the result of direct observation, is, of course, entitled to a controlling weight over the rather vague assumptions on which the provisional period suggested on p. 15 is based; and upon applying it to the same data, I find that a period of 261 days satisfies them much better than that of 288 days. Using the mean of the two simultaneously observed dates of maximum as the principal epoch, we have, as the best elements now attainable,

Min. 1891 Nov. 8; Max. 1892 Mar. 11.5 + 261^d *E*.

By these elements, a minimum was due 1892 July 26; and the following observations, lately obtained by me, may be of interest in this connection: 1892 Aug. 15.43, not seen; limit 10^M.5 ±; Aug. 21.41, held: 12^M ± ? Aug. 23.41, held; 11^M.0 ±; Aug. 29.40, 10^M.5 (moon 7 days); the star in each case being very low.

OBSERVATIONS OF THE SATELLITE OF *NEPTUNE*,

MADE WITH THE 26-INCH EQUATORIAL OF THE LEANDER McCORMICK OBSERVATORY.

By ORMOND STONE and N. M. PARRISH.

Date 1889	L. McC. M.T.	Posit'n Angle	No. of Meas.	L. McC. M.T.	Distance	No. of Meas.	Obs.
	h m			h m	″		
Oct. 28	11 15	131.3	9	. . .	. . .	. .	P
"	15 9	129.5	6	. .	. . .	. .	P
Nov. 24	13 16	266.9	6	13 31	13.21	2	P
Dec. 12	8 50	261.1	8	15 9	13.65	5	P
13	8 59	222.9	5	9 29	15.79	2	P
19	9 41	218.0	9	. . .	. . .	.	P
21	9 27	71.3	12	9 49	15.42	3	P
Dec. 23	9 51	320.3	12	9 53	8.66	2	P
1891							
Oct. 2	15 54	221.9	2	. . .	. . .	. .	S
Nov. 6	16 27	232.1	4	. . .	. . .	. .	S
30	11 41	219.9	2	12 13	14.46	2	S
Dec. 5	10 17	255.6	4	.	. . .	. .	S

P = N. M. Parrish; S = Ormond Stone.

OCCULTATION OF *MARS* AND *JUPITER* BY THE MOON IN SEPTEMBER.

By E. E. BARNARD.

The September moon occulted both *Mars* and *Jupiter* within less than a week of each other. Both occultations were observed with the 12-inch equatorial under favorable circumstances.

Observations of the Occultation of *Mars*, Sept. 3, 1892.

This being Saturday night, a large crowd of visitors were present at the Observatory. Just before the commencement of the occultation the visitors were requested to withdraw from the 12-inch dome, which they very courteously did.

The planet disappeared at the dark limb of the moon. The seeing was very fine = 5.

Disappearance.

		h	m	s	
1st contact	=	9	9	35.8	Observations good
Half obscured		9	10	4	
2d contact		9	10	37.1	

The planet faded slowly at the last contact, and seemed to flicker for a moment before the final disappearance. Just before disappearing, the light of the planet was of a pale blue.

No shadow-band or fringe to the moon's limb was seen where it crossed the planet. This phenomenon of a dusky diffused border to the moon's limb I had previously seen in an occultation of *Jupiter*, and so specially looked for it at this observation.

Reappearance.

		h	m	s	
3d contact	=	10	45	56.0	Perhaps 1 late
Half uncovered		10	26	17	
4th contact		10	26	52.5	

No shadow-band was seen in this case either. The planet appeared of a washed-out yellow, in contrast with the moon. The estimates for the time when the planet was one-half obscured should not have much weight, as it was rather difficult to decide when the disc was bisected, one-half being hidden by the moon.

Mt. Hamilton, 1892 *September* 9.

The times are Mt. Hamilton mean time, and were recorded by sidereal chronometer 1668, Mr. Townley having kindly compared the chronometer first after each set of observations.

Occultation of *Jupiter*, Sept. 9, 1892.

The occultation occurred in broad daylight, the reappearance not occurring until after sunrise. At immersion the seeing was very fine, = 5; but at reappearance the image of the planet was undulating. At disappearance the satellites took from $0^{s}.2$ to $0^{s}.3$ to be completely obscured. The times are for the centers of the satellites. At reappearance they were seen with difficulty, and not until they had left the limb some distance, and no times were recorded.

The disappearances were at the bright, and the reappearances from the dark limb.

When passing behind the moon a narrow shadow-band was noticed fringing the moon's limb where it cut the planet. I think this, which has been often seen at occultations of *Jupiter*, is due to contrast alone.

Disappearances of the Satellites.

	h	m	s
Satellite IV	17	10	48.5
Satellite II	17	23	1.1
Satellite I	17	24	22.8
Satellite III	17	38	30.3

Disappearance of Jupiter.

	h	m	s
Contact I	17	28	10.4
Half obscured	17	28	55
Contact II	17	29	15.7

Reappearance of Jupiter.

	h	m	s	
Contact III	18	33	17.5	Perhaps 2^{s} late
Half uncovered	18	33	50	
Contact IV	18	34	33.7	

The record for *Jupiter* is also in Mt. Hamilton M. T.

THE MOTION OF THE SOLAR SYSTEM.

By J. G. PORTER.

The present determination of the direction of the solar motion is based on the Catalogue of 1340 Proper-Motion Stars contained in Publication No. 12 of the Cincinnati Observatory. As this catalogue has already been distributed, it is only necessary to remark that, in the case of the few stars which are evidently physically connected, the mean was used.

For computing the coordinates of the apex of the sun's way the method given by Schönfeld in *V.J.S.* XVII, 256, was employed, the equations being put in the following form:

$$d\alpha\cos\delta = f\cos\delta + g\sin\alpha\sin\delta - h\cos\alpha\sin\delta + F\sin\alpha - G\cos\alpha$$

$$d\delta = -H\cos\delta + G\sin\alpha\sin\delta + F\cos\alpha\sin\delta + h\sin\alpha + g\cos\alpha$$

where

$f = \cos\omega\, d\epsilon + \cos i\, dl'$

$g = \sin\omega\, d\epsilon + \cos\Omega\sin i\, dl'$

$h = \sin\Omega\sin i\, dl'$

$$F = \frac{c}{\rho}\cos\tau\cos\sigma + \frac{R}{\rho}\,dl(\cos i\cos D\sin A + \cos\text{☊}\sin i\sin D)$$

$$G = \frac{c}{\rho}\cos\tau\sin\sigma - \frac{R}{\rho}\,dl(\cos i\cos D\cos A - \sin\text{☊}\sin i\sin D)$$

$$H = \frac{c}{\rho}\sin\tau \qquad - \frac{R}{\rho}\,dl\sin i\cos D\cos(A-\text{☊})$$

$d\alpha$, $d\delta$ = the proper motion of a star in R.A. and declination respectively.

The quantities in the above equations have the following significations:

$d\zeta$, the correction to the adopted precession.

ω, the obliquity of the ecliptic.

☊, i, the right-ascension of the ascending node of the milky way on the equator, and the inclination of the same planes.

dl, the change of the galactocentric longitude of a star measured in the plane of the milky way.

σ, τ, c, the coordinates of the apex of the sun's course, and the angular motion of the sun at distance unity.

α, δ, ρ, the heliocentric right-ascension, declination and distance of a star.

A, D, R, the similar galactocentric coordinates of the sun.

The time-unit for dl and c will of course be the same as that of the proper motions, namely the year.

It will be noticed that the coefficients of the right-ascension equations are the same as those of the declination-equations, except that each coefficient belongs to a different unknown quantity. In the arrangement of the normal equations the upper letters belong to the right-ascension equations, and the lower letters to the declination equations.

The stars were divided into four groups, as follows:

Group I,	yearly proper motion less than 0″.30,	576 stars.
Group II,	yearly proper motion 0″.30 to 0″.60,	533 stars.
Group III,	yearly proper motion 0″.60 to 1″.20,	142 stars.
Group IV,	yearly proper motion greater than 1″.20,	70 stars.

The computations were uniformly carried out to one more decimal place than is here given, and the check-equations were carried through independently by an assistant.

NORMAL EQUATIONS.

	$+f$	$+g$	$+h$	$+F$	$+G$		n	
	$-H$	$+G$	$-F$	$+h$	$-g$			n
I	+435.56	+16.04	+ 3.99	+ 17.55	+ 6.60	=	− 6.18	−56.06
	+ 16.01	+70.68	+ 1.15	+ 35.66	+ 3.37	=	+ 1.42	−10.14
	+ 3.99	+ 1.45	+69.56	+ 3.31	+ 51.01	=	− 6.60	− 2.95
	+ 17.55	+35.66	+ 3.31	+264.96	+ 8.12	=	+ 3.50	− 3.11
	+ 6 60	+ 3.37	+51.01	+ 8.12	+310.92	=	−27.18	− 1.02
II	+400.55	+ 3.32	+ 1.27	− 12.29	− 14.87	=	− 1.72	−77.22
	+ 3.32	+64.76	− 6.89	+ 29.83	− 3.83	=	− 0.81	−16.41
	+ 1.27	− 6.89	+67.10	− 3.83	+ 42.07	=	−12.04	− 1.49
	− 12.29	+29.83	− 3.83	+236.98	− 17.65	=	+12.77	− 2.57
	− 14.87	− 3.83	+42.07	− 17.65	+295.91	=	−66.06	+ 0.15
III	+ 97.81	+ 3.20	+ 3.92	− 5.30	− 3.68	=	+ 1.33	−32.28
	+ 3.20	+18.52	+ 2.20	+ 13.18	− 0.69	=	+ 0.30	−10.81
	+ 3.92	+ 2.20	+25.64	− 0.69	+ 7.10	=	− 4.20	− 4.10
	− 5.30	+13.18	− 0.69	+ 61.68	− 3.52	=	+ 9.36	− 3.12
	− 3.68	− 0.69	+ 7.10	− 3.52	+ 80.08	=	−34.88	− 2.85
IV	+ 44.58	+ 1.94	+ 3.03	− 5.31	− 2.14	=	+16.53	−45.10
	+ 1.94	+10.62	+ 1.82	− 1.74	+ 0.60	=	− 1.15	−11.79
	+ 3.03	+ 1.82	+13.80	+ 0.60	− 1.11	=	+ 6.86	− 8.95
	− 5.31	− 1.74	+ 0.60	+ 32.90	− 0.56	=	+ 2.42	+11.23
	− 2.14	+ 0.60	− 1.11	− 0.56	+ 36.06	=	−55.12	−11.47

The solution gives the following values, the combination weights being put in parentheses:

		f	g	h	F	G	H
I	α	−.011	+.021	−.035	+.014 (247)	−0.082 (273)	
	δ		−.007	+.012	+.039 (61)	− .124 (65)	+0.125
II	α	−.010	−.049	−.017	+.043 (223)	− .215 (268)	
	δ		+.006	+.010	+.040 (60)	− .253 (61)	+ .190
III	α	+.042	−.112	−.034	+.155 (52)	− .421 (78)	
	δ		+.018	+.037	+.051 (25)	−0.551 (15)	+ .310
IV	α	+.292	−.120	+.327	+.083 (32)	−1.498 (36)	
	δ		+.370	+.144	+.366 (13)	−0.827 (10)	+0.950

Since it is evident that dH is practically insensible, we place it zero, and find for the coordinates of the apex:

	I	II	III	IV
$F = \frac{c}{\rho}\cos\tau\,\cos\sigma$	+.019	+.042	+.121	+0.165
$G = \frac{c}{\rho}\cos\tau\,\sin\sigma$	—.090	—.222	—.414	—1.352
$H = \frac{c}{\rho}\sin\tau$	+.125	+.190	+.310	+0.950

		σ	τ	$\frac{c}{\rho}$
hence,	I	281.9	+53.7	0.16
	II	280.7	+40.1	0.30
	III	285.2	+34.0	0.55
	IV	277.0	+34.9	1.66

These results come remarkably near to those obtained by Dr. STUMPE in *A.N.* 2999–3000, excepting the declination of the first group, which is nearly 12° greater. The evidence for a common drift of the nearer stars seems to be strong.

Cincinnati Observatory, 1892 October.

FILAR-MICROMETER OBSERVATIONS OF COMET *a* 1892 (*SWIFT*),

MADE WITH THE 12-INCH EQUATORIAL OF VASSAR COLLEGE OBSERVATORY

BY MARY W. WHITNEY.

1892 Poughkeepsie M.T.	✳	No. Comp.	☄ — ✳ $\Delta\alpha$	☄ — ✳ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
July 20 11 7 39	1	6	+3 34.55	—2 57.8	1 2 3.55	50 22 46.7	n9.826	0.550
21 10 27 23	2	4	—1 11.88	+5 22.3	1 2 27.83	50 31 32.2	n9.823	0.657
23 10 19 14	3	16	+1 1.64	—3 39.8	1 3 7.23	50 49 21.9	n9.825	0.637
25 10 1 27	4	14	—0 7.42	—4 20.5	1 3 38.83	51 5 55.5	n9.826	0.654
26 9 57 12	4	14	+0 4.84	+3 35.6	1 3 51.09	51 13 51.8	n9.825	0.627

Mean Places for 1892.0 of Comparison-Stars.

✳	α	Red. to app. place	δ	Red. to app. place	Authority
1	0 58 27.86	+1.14	50 25 18.9	—1.4	Radcliffe 320
2	1 1 11.56	+1.15	50 26 14.0	—4.1	Oe. Arg. 1166.7
3	1 2 1.33	+1.26	50 53 5.1	—3.7	Bonn VI, 50°222
4	1 3 44.92	[illegible]	51 10 19.3	[illegible]	Oe. Arg. 1159

Comet faint. Seen with difficulty under wire-illumination.

OBSERVED MAXIMA AND MINIMA OF *W CYGNI* (CH. 7754), IN 1890–92.

BY EDWIN F. SAWYER.

The observations on this star extend from 1890 March 19, to 1892 August 29, and number 106. These observations when charted permit the determination of 7 maxima and 5 minima. When first seen on March 19, *W* was found to be 5 steps < DM. 44°3889, = DM. 43°4002, and 4 steps > DM. 45°3584, or $6^M.6$. The star was not again observed until May 11, when it was found quite bright, and evidently near a maximum, which phase was determined to have been passed about April 28. After May 11 the star rapidly declined, and a bright minimum was reached on July 2, the brightness being 4 steps < DM. 44°3889, = DM. 43°4002, and 3 steps < DM. 45°3584, or $6^M.6$. A slow increase was followed by a second maximum on August 20, which was quite faint, the brightness being = DM. 44°3889, and 4 steps > DM. 43°4002, or $6^M.35$. After a slow and somewhat irregular decrease, a rather faint minimum was passed Nov. 10, the brightness being 4 steps > DM. 43°4002, and 2 steps > DM. 45°3584, or about $6^M.9$. The light increased very rapidly after November 16, and a very bright maximum (the brightest I had yet observed) was reached 1891 January 7, the brightness being 4 steps < DM. 45°3558, and 3 steps > DM. 46°[illegible], or $5^M.75$. A very rapid decrease followed after January 9, the observations terminating on February 10. On April 28, observations were resumed, and *W* was found near a maximum, which phase was passed about May 15, this maximum being a fairly bright one. After a somewhat rapid, yet regular decrease, a minimum was reached on July 29, the brightness being 3 steps < DM. 43°4002, and 3 steps > DM. 45°3584, or about $6^M.65$. The light increased rapidly after August 8, and a fifth maximum of about the average brightness was passed on September 15, the brightness being 4 steps > DM. 44°3889, 1 step < DM. 46°[illegible], and 4 [illegible]

steps <DM. 15°3558, or 6$^{\rm M}$.0. A slow and irregular decrease until October 25, was followed by a rapid decline, and a very faint minimum was reached on December 8, the brightness being 5 steps <DM. 13°1002, and 2 or 3 steps <DM. 15°3581, or 7$^{\rm M}$.0. After a rapid rise, a sixth and fairly bright maximum was reached 1892 January 28. Observations discontinued from February 16 to May 16. When resumed on May 16, H^{V} was found quite bright. A rapid rise followed, and another very bright maximum was passed on June 2, the brightness being 3 steps <DM. 45°3558, and 2 or 3 steps >DM. 16°3305, or 5$^{\rm M}$.7. The star remained at maximum only a few days, when it very rapidly faded, and another very faint minimum was reached on August 12, the brightness being 5 steps <DM. 43°4002, and 2 or 3 steps <DM. 15°3581, or 7$^{\rm M}$.0. The fluctuations in brightness during the past two years have been more marked than I have previously observed, or from 5$^{\rm M}$.7 to 7$^{\rm M}$.0. The intervals between the maxima range from 111 to 140 days, the average being about 128 days; while the intervals between the minima range from 126 to 141 days, the average being about 130 days.

Brighton, Mass., 1892 August 31

OBSERVATIONS OF COMET *a* 1892 (SWIFT).

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 9.6-INCH EQUATORIAL.

BY PROF. E. FRISBY.

Communicated by the Superintendent.

1892 Washington M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
Sept. 16 8 59 18.7 (d h m s)	1	25 , 5	−1 12.41 (m s)	−0 16.5 (′ ″)	0 21 41.37 (h m s)	+50 42 1.2 (° ′ ″)	*n*9.769	9.551
26 10 18 32.5	2	19 , 4	−1 2.20	−9 21.8	0 9 5.59	+48 34 43.1	*n*9.381	*n*8.816
30 7 29 36.5	3	19 , 4	−1 41.42	+3 18.4	0 4 41.40	+47 36 39.7	*n*9.733	9.798

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	0 23 20.83 (h m s)	+2.95 (s)	+50 42 4.8 (° ′ ″)	+12.9 (″)	Bonn VI, +50°82
2	0 10 4.85	+2.94	+48 43 18.3	+16.6	Bonn VI, +48°53
3	0 6 19.89	+2.93	+47 33 3.2	+18.1	Radcliffe 16

OBSERVATIONS OF COMETS.

MADE AT THE HARVARD COLLEGE OBSERVATORY,

BY O. C. WENDELL, ASSISTANT.

[Communicated by Professor E. C. PICKERING, Director.]

1892 Cambridge M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
			COMET *a* 1882 (SWIFT.)					
May 18 13 59 10 (d h m s)	1	5	+1 28.33 (m s)	+ 5 9.0 (′ ″)	23 22 0.80 (h m s)	+31 31 2.3 (° ′ ″)	*n*9.707	0.668
24 14 1 17	2	5	+2 30.91	+ 3 48.6	23 36 58.27	+34 25 18.9	*n*9.717	0.629
June 15 12 21 10	3	5	−1 58.59	+ 0 47.0	0 22 13.23	+42 33 2.8	*n*9.771	0.682
July 20 10 52 16	4	5	−2 8.52	− 3 33.4	1 2 4.07	+50 22 37.8	*n*9.836	0.607
23 11 18 51	5	5	−3 19.21	−12 8.2	1 3 9.71	+50 49 41.5	*n*9.837	0.501
Sept. 2 10 31 46	6	5	−1 18.12	− 0 23.4	0 39 56.38	+52 32 31.1	*n*9.736	9.356
			COMET *d* 1892 (DENNING.)					
Sept. 1 13 5 12	7	5	−0 32.39	+0 37.4	6 9 1.66	+31 35 51.2	*n*9.709	0.724
2 14 58 13	8	5	−0 20.64	+5 19.6	6 11 12.48	+31 29 39.6	*n*9.669	0.562

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	23 20 32.89	—0.42	+31 26 5.4	—12.1	W. Bessel XXIII, 580
2	23 34 27.72	—0.36	+31 21 32.3	— 2.0	W. Bessel XXIII, 707
3	0 24 41.82	0.00	+12 32 24.9	— 9.1	B.B. Vol. VI, 12°89
4	1 4 11.48	+1.11	+50 26 13.9	— 3.0	Oe.A, 1166–7
5	1 6 27.68	+1.24	+51 1 53.1	— 3.7	Oe.A, 1221–2
6	0 41 11.76	+2.71	+52 32 46.9	+ 7.6	Oe.A, 731
7	6 9 34.36	—0.31	+31 35 9.4	+ 1.4	W. Bessel VI, 178, 9
8	6 12 3.31	—0.19	+31 24 15.6	+ 1.1	W. Bessel VI, 258

REMARKS

Comet *a* 1892 (Swift).

1. Coma somewhat elongated. 2. Sky somewhat hazy; nucleus rather faint; no definite structural detail visible. 3. Nucleus pretty well defined, and rather small; total diameter of coma, 4′. 4. Diameter of coma, 4′. Nucleus apparently a little eccentric. 6. Nucleus fairly well defined.

Comet *d* 1892 (Denning).

1. Comet faint, 12th magnitude. No tail. Nucleus pretty well defined.

COMET *d* 1892 (*BROOKS*).

A continuation of the ephemeris of this comet, extending from Oct. 10 to 23, was sent by Father Searle, but arrived just too late for insertion in no. 275 of the Journal. The correction required, Oct. 7, was about —3s and +1′. From the same system of elements, as given on p. 86, the ephemeris has been further continued by Mr. Whitaker.

EPHEMERIS OF COMET *d* 1892, FROM SEARLE'S ELEMENTS.

BY GEORGE F. WHITAKER.

Gr. M.T.	App. α	App. δ	log Δ	Br.
1892	h m s	° ′		
Oct. 21.5	8 35 37	+18 41.4	0.0966	6.72
22.5	39 11	17 41.5		
23.5	42 47	17 7.6	.0851	
24.5	46 25	16 32.7		
25.5	50 4	15 56.9	.0743	7.94
26.5	53 45	15 20.1		
27.5	8 57 29	14 42.2	.0632	
28.5	9 1 14	14 3.3		
29.5	5 2	13 23.3	.0523	9.37
30.5	8 52	12 42.3		
31.5	12 44	12 0.2	.0416	
Nov. 1.5	16 38	11 17.1		
2.5	20 34	10 32.9	.0312	11.01
3.5	24 32	9 47.6		
4.5	28 33	9 1.2	.0211	
5.5	32 36	8 13.8		
6.5	36 42	7 25.3	.0113	12.88
7.5	40 50	6 35.7		
8.5	9 45 0	+ 5 45.1	0.0019	
Nov. 9.5	9 49 13	+ 4 53.5		
10.5	53 28	4 0.9	9.9930	14.95
11.5	9 57 46	3 7.4		
12.5	10 2 6	2 12.9	.9847	
13.5	6 28	1 17.5		
14.5	10 53	+ 0 21.3	.9770	17.17
15.5	15 20	— 0 35.7		
16.5	19 50	1 33.5	.9699	
17.5	24 23	2 32.0		
18.5	28 58	3 31.1	.9636	19.46
19.5	33 36	4 30.8		
20.5	38 16	5 31.0	.9580	
21.5	42 59	6 31.6		
22.5	47 44	7 32.6	.9533	21.71
23.5	52 32	8 33.9		
24.5	10 57 23	9 35.3	.9494	
25.5	11 2 16	10 36.8		
26.5	11 7 12	—11 38.4	9.9461	23.79

COMET *e* 1892 (*BARNARD*).

A very faint comet was photographically found, Oct. 12, by Barnard, at the Lick Observatory.

The observed position on the next night was

1892 Oct. 13.638 Gr. M.T. $\alpha = 19^h\ 33^m\ 56^s$, $\delta = +12°\ 33'$.

Daily motion, $+1^m\ 41^s$ in α, and 37′ southward.

Subsequent telegrams give the position, Oct. 15, as also elements and ephemeris computed by Prof. Campbell from observations of Oct. 15, 16 and 17. The orbit is naturally uncertain.

1892 Oct. 15.7125 Gr. M.T. $\alpha = 19^h\ 38^m\ 23^s.8$, $\delta = +11°\ 43'\ 35''$.

Elements.

T = 1892 Aug. 26.44 Greenw. M. T.
ω = 111° 2′
Ω = 181 13
i = 43 7
q = 1.9904

Ephemeris for Greenwich Midnight.

	α	δ	Br
	h m s	° ′	
Oct. 18.5	19 44 36	+10 42	0.85
22.5	19 53 32	9 17	
26.5	20 2 28	7 56	
30.5	20 11 24	+ 6 41	0.69

EPHEMERIS OF COMET *a* 1892 (*SWIFT*).

(Continued from page 80.)

Gr. M.T. 1892	App. α h m s	App. δ ° ′	log Δ	Br.	Gr. M.T. 1892	App. α h m s	App. δ ° ′	log Δ	Br.
Oct. 20.5	23 48 38.1	+41 51.7	0.3415	0.037	Nov. 4.5	23 14 13.3	+37 30.8		
21.5	48 8.3	41 36.5			5.5	8.7	37 14.1	0.3859	0.027
22.5	47 40.3	41 18.4			6.5	5.6	36 57.6		
23.5	47 14.1	41 0.4			7.5	4.0	36 41.2		
24.5	46 49.7	40 42.5	.3520	.034	8.5	3.9	36 25.0		
25.5	46 27.1	40 24.6			9.5	5.3	36 8.9	.3980	.025
26.5	46 6.2	40 6.8			10.5	7.9	35 53.0		
27.5	45 47.0	39 49.1			11.5	11.9	35 37.3		
28.5	45 29.5	39 31.4	.3628	.032	12.5	17.3	35 21.8		
29.5	45 13.7	39 13.9			13.5	23 14 24.1	+35 6.4	0.4104	0.023
30.5	44 59.6	38 56.4							
31.5	47.4	38 39.0							
Nov. 1.5	36.8	38 21.8	0.3742	0.029					
2.5	27.0	38 4.7							
3.5	23 44 19.1	+37 47.7							

A comparison of the ephemeris on p. 80 with Prof. Frisby's observation of Sept. 30 gives,

O—C. $\Delta\alpha = -0^s.9$, $\Delta\delta = -0'.4$

NEW ASTEROIDS.

Dr. Kreutz has kindly communicated the following information received by the *Central-Stelle* relative to small planets recently found.

1892 *D*. Telegram from Mr. Perrotin at Nice, Sept. 21,

"Planet photographed by Charlois Sept. 19, observed at Nice
Sept. 20 $9^h\ 10^m.3$ M.T. $\alpha = 7°\ 25'\ 3''$, $\delta = +11°\ 25'\ 15''$. 12M. Daily motion, $-12'$ in α, and 6′ southward.
This is not *Meliboea*, which is upon the same plate. It may be new."

This planet is very probably a new one.

1892 *E*. Telegram from Mr. Perrotin at Nice, Sept. 25,

"Planet photographed by Charlois, Sept. 22 and 23, observed at Nice
Sept. 24 $12^h\ 0^m$ M.T. $\alpha = 11°\ 38'$, $\delta = +8°\ 35'$. 11½M. Daily motion, $-14'$ in α, none in δ."

1892 *F*. Telegram from Mr. Perrotin at Nice, Sept. 28,

"Planet photographed by Charlois, Sept. 25 and 26, observed at Nice
Sept. 27 $7^h\ 51^m.8$ M.T. $\alpha = 9°\ 51'\ 56''$, $\delta = -14°\ 13'\ 39''$. 12M. Daily motion $-14'$ in α, and 2′ southward."

1892 *G* and *H*. Communication from Mr. Berberich, received Sept. 29.

"Two planets photographed by Wolf, Sept. 25 $9^h\ 38^m$ Gr. M.T.
G 12M. $\alpha = 0^h\ 36^m.6$, $\delta = +0°\ 21'$; daily motion $-11'$ in α, and 10′ southward.
H 12M. $\alpha = 0^h\ 37^m.6$, $\delta = +1°\ 2'$; daily motion $-11'$ in α, and 6′ southward."

Both of these positions are referred to the mean equinox of 1892.0.

1892 *J*. 12M. Also photographed by Wolf at Heidelberg Sept. 25.
Sept. 30 12^h Berlin M.T. $\alpha = 0^h\ 21^m.7$, $\delta = -2°\ 50'$. Daily motion, $-15'$ in α, and 1′ southward.

CONTENTS.

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ON THE VARIATION OF LATITUDE, VII.

BY S. C. CHANDLER

We now come upon a new line of investigation. Heretofore, as has been seen, the method has been to condense the results of each series of observations into the interval comprised by a single period, then to determine the mean epoch of minimum and the mean range for each series, and finally, by a discussion of these quantities, to establish the general character of the law of the rotation of the pole. It is now requisite to analyze the observations in a different way, and discover whether the deviations from the general provisional law, in the last column of Table II, are real, and also in what manner the variation of the period is brought about. The outcome of this discussion, which is to be presented in the present paper, is extremely satisfactory. The real nature of the phenomenon is most distinctly revealed, and may be described as follows.

1. The observed variation of the latitude is the resultant curve arising from two periodic fluctuations superposed upon each other. The first of these, and in general the more considerable, has a period of about 427 days, and a semi-amplitude of about 0″.12. The second has an annual period, with a range variable between 0″.04 and 0″.20 during the last half-century. During the middle portion of this interval, roughly characterized as between 1860 and 1880, the value represented by the lower limit has prevailed, but before and after those dates, the higher one. The minimum and maximum of this annual component of the variation occur, at the meridian of Greenwich, about ten days before the vernal and autumnal equinoxes, respectively, and it becomes zero just before the solstices.

2. As the resultant of these two motions the effective variation of the latitude is subject to a systematic alteration in a cycle of seven years' duration, resulting from the commensurability of the two terms. According as they conspire or interfere, the total range varies between two-thirds of a second as a maximum, to but a few hundredths of a second, generally speaking, as a minimum.

3. In consequence of the variability of the coefficient of the annual term above mentioned, the apparent average period between 1840 and 1855 approximated to 380 or 390 days; widely fluctuated from 1855 to 1865; from 1865 to about 1885 was very nearly 427 days, with small fluctuations; afterwards increased to near 440 days, and very recently fell to somewhat below 400 days. The general course of these fluctuations is quite faithfully represented by the law of eq. (3), (no. 267), and accurately, even down to the minor oscillations of individual periods, by the law of eq. (15), hereafter given, and verbally interpreted above. This law also gives a similarly accurate account of the corresponding oscillations in the amplitude. The closeness of the accordance between observation and the numerical theory, in both particulars, places the reality of the law beyond reasonable doubt.

To proceed to the methods by which the above results have been established, the values of the latitude-deviations indicated by the individual groups of observations in each of the forty-nine series — which have been condensed into a few equations for each series in the tables on pp. 58–62, 65–68, 72 — were first reduced to the correct mean values of the latitude for each series by subtracting the values of x there given. The corresponding dates were reduced to the date of the phase at the Greenwich meridian by adding the values of $\frac{\lambda}{\theta}$, eq. (6). The results were then tabulated chronologically in 20-day groups, for the whole period from 1837 to 1892. Weights were applied according to the quality and number of the observations, by means of the following tables, where p is the weight assigned to the series, ϵ that of a given number of observations of a series having the weight p, and N is the number of the observations.

TABLE X. WEIGHTS.

Ser.	p	Ser.	p	Ser.	p	Ser.	p	Ser.	p
1	1	10	1	19	1	27	1	37	[illegible]
2	3	11	1	20	1	28	1	38	[illegible]
3	1	12	1	21	1	29	1	39	[illegible]
4	3	12a	1	22	1	30	1	40	[illegible]
5	3	13	1	22a	1	31	3	41	[illegible]
6	1	14	3	23	3	32	1	42	1
7	2	15	2	24	1	33	2	43	1
8	1	16	1	25	1	34	2	44	1
9	1	17	3	26	1	35	1	45	5
9a	1	18	1	26a	1	36	3		

	$p=1$	$p=2$	$p=3$	$p=4$
w	N	N	N	N
1	1– 3	1	1	1
2	4– 7	2– 3	2	1
3	8– 12	4– 6	3– 4	2– 3
4	13– 18	7– 9	5– 6	4
5	19– 25	10– 12	7– 8	5– 6
6	26– 34	13– 17	9– 11	7– 8
7	35– 46	18– 23	12– 15	9–11
8	47– 60	24– 30	16– 20	12–15
9	61– 75	31– 37	21– 25	16–19
10	76–100	38– 50	26– 33	20–25
11	101–140	51– 70	34– 38	26–35
12	141–200	71–100	39– 68	36–50
13	201–300	101–150	69–100	51–75
14	300 and over	151 and over	101 and over	76 and over

The mean values for all the 20-day groups were then taken, by weights, in three ways: *A*, for the series 2, 4, 5, 6, 7, 11, 13, 14, 15, 16, 17, 23, 29, 31, 33, 34, 36, 37, 41, 42, 43, 44, 45: *B*, for the series 1, 3, 8, 9, 9*a*, 10, 12, 12*a*, 18, 19, 20, 21, 22, 22*a*, 24, 25, 26, 26*a*, 27, 28, 30, 32, 35, 38, 39; *C*, for the whole data combined. The separation into the groups *A* and *B* was for the purpose of ascertaining whether these totally distinct series of observations would mutually confirm each other, and thus establish the degree of confidence which could be placed on the results. While in general the observations which were presumably of the highest excellence were placed in class *A*, this rule was subordinated to the idea of obtaining as nearly as possible a continuous record of the phenomenon in both classes.

Take first the results of the combined data, *C*. To diminish the effect of accidental error in the 20-day groups, the mean values of each three successive groups were combined with those of the corresponding means of groups situated respectively about 400 days before and after, which represent approximately the same phase of the latitude-variation. It is hardly necessary to say that this process is entirely unobjectionable, since any error in the assumption as to the period which it involves eliminates itself almost completely from the means. We thus obtain a series of adjusted mean observed values of $\Delta\varphi$, at 20-day intervals, for the whole period under discussion, from which the accidental errors are very largely eliminated. A plotting of them presents a nearly continuous graphical representation of the course of the latitude-variation during somewhat more than half a century. Upon inserting in this chart the course of the curve computed from equations (3), (4) and (5), the most casual inspection suffices to show the fidelity with which the latter follows the observed phenomenon throughout the whole interval. It requires but little attention to perceive, with equal clearness, that systematic deviations are present. The most characteristic of these corresponds to what I had previously discerned in discussing the individual series, and described a year ago (XI, 86). For a few years the 427-day fluctuation emerges unmistakeably, then for a while obscurely, to reappear in full force. This phenomenon recurs so regularly as to make it plain that, in addition to the 427-day period, a perturbation exists which is a function of the sun's longitude.

Another characteristic of the phenomenon to which attention was called in the place just cited, was "that the variations in the length of the period seem to go hand in hand with simultaneous alterations in the amplitude of the rotation; the shorter periods being apparently associated with the larger coefficients for the latter." How well this inference is now borne out may be seen from the following analysis of the average values of r according to the length of the periods, as given in Table XI.

Period	Obs'd r	Comp. r
	$''$	$''$
Under 390	0.20	0.20
390–420	.18	.19
420–450	.15	.13
Over 450	0.10	0.08

In the place cited it was remarked, with reference to the two peculiarities just noticed, that, "if confirmed these relations will afford a valuable touchstone, in seeking for the cause of a phenomenon which now seems to be at variance with the accepted laws of terrestrial rotation." It is interesting to observe that the actual discovery of the real character of the phenomenon has in fact been reached through the very channels thus foreshadowed.

The next essential step was to break up the whole series into groups of eighteen or twenty 20-day means each, representing individual periods, the minima being symmetrically situated near the middle, and to determine by least-squares, from the formulas of p. 18, the epoch of minimum, and range, for each period. The results of these solutions are placed in Table XI, column *C*.

The mutually independent classes *A* and *B* were treated in the same manner, with this difference, — that the adjusted means employed in the least-square solutions were found by merely taking means of three successive values of the 20-day groups, without combining them with the corresponding means of the like phases in the periods immediately before and after, as in *C*. The results are placed in columns *A* and *B*. Their comparison shows an agreement which is very remarkable when the minuteness of the quantities with which we are dealing is kept in mind. Indeed, it is so great that substantially the same numerical coefficients would be derived, in the formulas hereafter to be given, if we should employ either of these independent sets of data to the exclusion of the other. This fact seems to justify a very important conclusion, that the results of astronomical observation possess a refinement and freedom from systematic instrumental error which we have not been accustomed to accord them. It instils a confident hope that the ultimate degree of accuracy attainable in such measurements may be much higher than has been supposed, and is full of promise for the future astronomy of precision.

TABLE XI. OBSERVED AND COMPUTED SEMI-AMPLITUDES AND MINIMUM-EPOCHS.

Equation (3)		A		B		C		Equation (4)			
E	*T*	*r*	*T*	*r*	*T*	*r*	*T*	*r*	*T*		
−34	2392715	. . .	. . . . .	0.40	2392680	0.31	2392689	0.41	2392820	=	1839 Mar. 20
33	3087	. . .	. . . . .	.36	3075	.27	3082	.26	3200	=	40 Apr. 4
32	3462	0.03	2393381	.40	3401	.08	3507	.19	3558	=	41 Mar. 28
31	3839	.05	3844	.64	3899	.11	3890	.11	3900	=	42 Mar. 5
30	4216	.10	4310	.59	4262	.14	4258	.17	4242	=	43 Feb. 10
29	4591	.07	4667	.56	4625	.17	4620	.26	4610	=	44 Feb. 13
28	4973	. . .	. . . . .	.40	4971	.28	4978	.30	4998	=	45 Mar. 5
27	5354	. . .	. . . . .	.33	5358	.34	5352	.27	5377	=	46 Mar. 21
26	5735	. . .	. . . . .	.09	5683	.20	5748	.18	5762	=	47 Apr. 10
25	6118	. . .	. . . . .	.29	6229	.20	6228	.07	6115	=	48 Mar. 28
24	6502	. . .	. . . . .	.34	6633	. . .	. . . . .	.06	6420	=	49 Jan. 27
23	6888	. . .	. . . . .	.05	6714	. . .	. . . . .	.16	6790	=	50 Feb. 1
22	7271	. . .	. . . . .	.34	7121	. . .	. . . . .	.22	7170	=	51 Feb. 16
21	7662	. . .	. . . . .	.22	7498	.18	7519	.23	7558	=	52 Mar. 10
20	8052	. . .	. . . . .	.25	7941	.19	7889	.18	7958	=	53 Apr. 14
19	8442	. . .	. . . . .	.05	8392	.05	8319	.08	8360	=	54 May 21
18	8831	. . .	. . . . .	.09	8868	.11	8851	.07	8960	=	56 Jan. 11
17	9227	. . .	. . . . .	.24	9272	.24	9272	.15	9340	=	57 Jan. 25
16	2399622	. . .	. . . . .	.28	2399675	.28	2399678	.18	2399737	=	58 Feb. 26
15	2400018	.12	2400059	.24	2400086	.22	2400100	.17	2400140	=	59 Apr. 5
14	0415	.27	0473	.49	0493	.22	0484	.12	0550	=	60 May 19
13	0811	.18	0900	.16	0954	.12	0963	.07	1015	=	61 Aug. 27
12	1244	.24	1268	.18	1032	.05	1300	.11	1487	=	62 Dec. 12
11	1616	.05	1434	.10	1534	.06	1513				
10	2020	.16	1939	.08	1937	.11	1941	.15	1900	=	64 Jan. 29
9	2425	.18	2319	.10	2365	.15	2344	.16	2312	=	65 Mar. 16
8	2832	.18	2749	.24	2828	.15	2780	.14	2725	=	66 May 3
7	3240	.10	3142	.13	3176	.14	3186	.10	3154	=	67 July 6
6	3650	.14	3679	.18	3644	.16	3631	.09	3617	=	68 Oct. 12
5	4062	. . .	. . . . .	.16	4049	.17	4056	.12	4060	=	69 Dec. 28
4	4476	.24	4500	.24	4480	.23	4481	.15	4460	=	71 Feb. 1
3	4892	.19	4905	.14	4879	.20	4922	.45	4882	=	72 Mar. 29
2	5309	.17	5339	.04	5237	.05	5328	.12	5305	=	73 May 26
− 1	5729	.46	5709	.02	5782	.08	5753	.08	5752	=	74 Aug. 16
0	6150	.11	6103	.15	6218	.12	6174	.40	6215	=	75 Nov. 22
+ 1	6574	.15	6596	.26	6636	.21	6616	.15	6645	=	77 Jan. 25
2	7000	.22	7044	.30	7019	.20	7032	.17	7060	=	78 Mar. 15
3	7428	.06	7171	.16	7475	.18	7185	.15	7462	=	79 Apr. 22
4	7858	.03	7775	.18	7844	.11	7836	.10	7875	=	80 June 8
5	8290	.44	8338	.04	8236	.06	8321	.07	8390	=	81 Nov. 5
6	8725	.19	8751	.14	8944	.07	8715	.14	8821	=	83 Jan. 10
7	9162	.17	9101	.29	9221	.14	9138	.20	9225	=	84 Feb. 18
8	2409602	.33	2409536	0.43	2409633	.19	2409604	.24	2409628	=	85 Mar. 27
9	2410044	. . .	. . . . .	. . .	. . . . .	. . .	. . . . .	.16	2410022	=	86 Apr. 25
10	0489	. . .	. . . . .	. . .	. . . . .	. . .	. . . . .	.07	0400	=	87 May 8
11	0937	. . .	. . . . .	. . .	. . . . .	. . .	. . . . .	.11	1020	=	89 Jan. 17
12	1387	.21	2411402	. . .	. . . . .	.21	2411402	.22	1410	=	90 Feb. 11
+13	2411840	0.23	2411783	. . .	. . . . .	0.23	2411783	0.27	2411800	=	1891 Mar. 8

The subsequent computations are based on the combined data, *C*. Pursuing the hypothesis already suggested, the observed values of $k\varsigma$ were divided into groups, whose mean date is indicated in the first column of Table XII, and the limits of the groups in the second column. The numerical constants were then determined for the several groups according to the general formula,

$$\varsigma - \varsigma_0 = r\cos(T-\theta) + r'\cos(\odot - G) \qquad (4)$$

where the first term of the second member involves the 127-day variation, and the second term depending on the sun's longitude, *G* being the longitude of the sun at *T* when this term is a negative minimum. These constants are given in Table XII. Those for the first three groups have been given only half-weight in the following discussion.

TABLE XII. CONSTANTS OF THE FORMULA FOR VARIOUS EPOCHS.

Date	Limits	r_1	O−C	T_1	O−C	r_2	O−C	T_2	O−C
1843	2393090–5590	0.051	−0.069	2394152	+27	0.170	−0.037	2394253	−18
1858	8410–0910	.187	+ .067	2399684	−44	.080	+ .012	2399675	−75
1861	2399670–2170	.115	− .005	2400554	−36	.132	+ .088	2400853	+ 7
1864	2400930–3430	.090	− .030	1922	+39	.046	+ .002	2028	+80
1868	2190–4690	.159	+ .039	3206	+30	.037	− .001	3402	0
1872	3450–5950	.137	+ .017	4480	+11	.033	− .007	4836	−27
1875	4710–7210	.105	− .015	5778	+16	.052	+ .005	5944	−15
1878	5970–8470	.148	+ .028	7043	−12	.032	− .023	7079	+24
1882	2407270–9770	.110	− .010	2408314	−34	.052	− .028	2408528	+12
1890	2411050–2170	0.105	−0.015	2411390	+25	0.184	+0.036	2411401	−37

An examination of the results of these solutions seems to establish the truth of the hypothesis. From the intervals of T_1 and T_2 we find,

427-day Term	Annual Term
$5532^d = 13 \times 425^d.5$	$5422^d = 15 \times 361^d.5$
$870 = 2 \times 435.0$	$1178 = 3 \times 392.7$
$1368 = 3 \times 456.0$	$1175 = 3 \times 391.7$
$1284 = 3 \times 428.0$	$1374 = 4 \times 343.5$
$1274 = 3 \times 424.7$	$1434 = 4 \times 358.5$
$1298 = 3 \times 432.7$	$1108 = 3 \times 369.3$
$1265 = 3 \times 421.7$	$1135 = 3 \times 378.3$
$1271 = 3 \times 423.7$	$1449 = 4 \times 362.2$
$3076 = 7 \times 439.4$	$2873 = 8 \times 359.1$

The accordance of the various values of the two periods is very striking, and, as there is nothing in the process of determining them which would constrain it, or sophisticate the agreement, it seems that we must admit the terms to be genuine.

Taking the means of r_1 and r_2 as indicated in the first column below, we find,

Groups	r_1 ″	r_2 ″
1843, 58, 61	0.118	0.127
1864, 68	.124	.042
1872, 75	.121	.042
1878, 82	.129	.042
1890	0.105	0.184

The differences among the values of r_1 are extraordinarily small, and its mean value appears to be fixed with great precision, so that there is no reason to regard it as inconstant, for this period of half a century, at least. The coefficient r_2, on the contrary, is manifestly variable. For the interval from about 1862 to 1882, indeed, it appears to be practically constant; but, from another inquiry into this point, I am convinced that before and after these dates its value was actually much larger; as is shown above, although the question whether the change was a gradual or an abrupt one can only be answered after further investigation.

It is convenient to have a general numerical formula, for comparison with the whole series of observations, to aid in further investigation of the subject. I therefore adopt provisionally, for the Greenwich meridian,

$$\varphi - \varphi_0 = -0''.12 \cos(t - T_1) \times 0^\circ.835 - r_2 \cos(\odot + 10^\circ) \qquad (15)$$

where

$$T_1 = 2406193 \,(1875 \text{ Nov. } 1) + 431E \qquad (16)$$

$$r_2 = 0''.047 + 0''.003\,\tau + 0''.00025\,\tau^2 \qquad (17)$$

τ being the interval in years, positive after 1875.

The deviations O−C in Table XII correspond to the values of the constants here assumed.

A considerably closer representation of the observations between 1862 and 1882 is obtained by the simpler formula,

$$\varphi - \varphi_0 = -0''.125 \cos(t - 2\,406\,191) \times 0^\circ.843 - 0''.050 \cos(\odot + 10^\circ) \qquad (18)$$

since for this interval the period may be taken as uniformly 427 days. Thus, if we compare the values of T_1, in Table XII, for this interval, with the expression $T_1 = 2406191 + 427E$, we have,

Date	E	O−C
1864	−10	$+ 1^d$
1868	− 7	+ 4
1872	− 4	− 3
1875	− 1	+14
1878	+ 2	− 2
1882	+ 5	−12

A closer correspondence could not be desired.

A very important conclusion necessarily follows from the agreement of the values of the 427-day term deduced from the intervals between the consecutive values of T_1 in Table XII: namely, that there has been no discontinuity in this revolution,—such as Prof. NEWCOMB regarded as so probable that he doubted the possibility of drawing any conclusions from the comparison of observations before and after 1860 (*A J.* 271, p. 50).

The present investigation demonstrates that the way out of the apparently irreconcileable contradiction of theory and observation in this matter, does not lie in the direction of discrediting the observations, as he is inclined to do. On the contrary, the result is a beautiful vindication of the trustworthiness of the latter, and at the same time of the theory that demands an invariable rate of motion: providing a perfectly fitting key to the riddle, by showing that another cause has intervened to produce the variability of

the period. I feel confident that Prof. Newcomb will agree to the reality of the explanation here set forth, and will reconsider his view that the perturbations in the position of the pole must be of the nature of chance accumulations of motion, a view which he then considered necessary to the maintenance of the constancy in the period of latitude-variation.

Thus theory and observation are again brought into complete accord, and it now only remains to ascertain the true nature and physical origin of the term which apparently depends on the sun's longitude. In speculations on this subject it seems desirable to hold to a prudent reserve until further investigations have been presented in the next paper, by which it is hoped that considerable light will be thrown upon the question.

Meanwhile the accompanying charts have been prepared to exhibit the nature of the changes which have been going on during the last half-century, and the satisfactory account which the above theory gives of them. The upper left-hand chart gives, in the heavy line, the observed values of the semi-amplitude in column C of Table XI. The fainter line gives the values according to formula (15), deduced by taking, from the curve representing it, half of the difference between the value at each minimum and the mean of the values at the maxima immediately preceding and following. On the lower left-hand chart the heavy line gives the deviations of the Greenwich times of minima, T, in column C of Table XI, from the formula on p. 70, no. 273, $T = 2406291 + 409E$, which is the best uniform period which will satisfy all the observations from 1840 to 1892. The dotted line gives the corresponding [illegible] of [illegible] no. 267, and emphasizes how sat[illegible] represented the observations as regards [illegible]. The faint continuous line represents [illegible] On the right-hand chart the heavy line gives [illegible]ations by observation, according to the [illegible] described on p. 98, and the fainter continuous [illegible] by eq. (15). The small squares represent [illegible] nates. The curve is prolonged to [illegible] (Julian day = 2413000) in order to exhibit [illegible] nature of the variations during the next year or two.

It is needless to comment upon the [illegible] all three charts, the theory adheres to observation [illegible] careful inspection will carry the conviction [illegible] general nature of the true law is before us. It [illegible] out, however, that the places where systematic [illegible] appear — the most notable instance of which [illegible] 2399000 and 2400500, (1856–1860) — [illegible] where the observed data are most defective, [illegible] we have yet no warrant to assume that the [illegible] the formula are actually constant in nature, or [illegible] strictly continuous law. Indeed, it is [illegible] that, so far as they depend on meteorological causes, [illegible] is not the case; and it is hoped, in the next paper, to show that real deviations from a continuous law actually do exist. Nevertheless, the result of the comparison between the formula and the observations seems to demonstrate [illegible] observed variations of latitude are amenable to a comparatively simple law to a degree far beyond anything that could have been anticipated.

OBSERVATIONS OF THE PARTIAL SOLAR ECLIPSE OF 1892 OCT. 20,

MADE AT THE ALLEGHENY OBSERVATORY

(Communicated by James E. Keeler, Director.)

The observations of this eclipse were made under favorable conditions. Light, hazy clouds covered the sun at both contacts, but they were too thin to obstruct much light, and the definition was very fair. The times of contact and corresponding position-angles had been previously computed by Prof. Very, from the data given in the *American Ephemeris*, and were as follows:

	h m s			
First cont..	23 59 7.1	E. Time.	Pos.-Angle	273 12 42
Last cont.,	2 58 33.2	"	Pos.-Angle	103 5 1

Observations by J. E. Keeler.

The thirteen-inch equatorial was used, with aperture reduced to eight inches, and a polarizing eyepiece, power 120. Times were recorded on a chronograph by the Frodsham sidereal clock, which was compared after each observation with the standard mean time clock.

First contact (quite steady) [illegible]

Last contact, general tangency of limbs, [illegible]

Last contact, peak of last lunar mountain, [illegible]

Observations by F. W. Very.

The instrument was a fo[illegible] by Mr. Brashear, with [illegible] [illegible] were noted by [illegible] with the standard [illegible]

First contact, estimated 20 [illegible]

Last contact, bases of lunar mountains [illegible]

Last contact, peaks of lunar mountains [illegible]

Observations by J. A. Brashear.

Mr. Brashear's observations w[illegible]

shop, at a point about 200 yards from the Allegheny Observatory, in the direction N. 30° W. The instrument was a six-inch equatorial, with polarizing eyepiece, power 70. Times were recorded by a good watch, which was compared with the standard mean time clock before and after the eclipse.

	h m s
First contact,	23 59 5.4 E. Time
Last contact, general tangency of limbs,	2 58 12.8 "

Corrections to the Allegheny Observatory Time-Signals.

As the time-signals of the Allegheny Observatory are used throughout the Pennsylvania Railroad system, their corrections at the times of contact are given below for the benefit of persons who may have used them in observing the eclipse. The clock is regulated to Eastern Standard Time.

At 0^h Oct. 20, 1892, $\Delta T = -0^s.14$

At 3^h Oct. 20, 1892, $\Delta T = -0^s.11$

PHOTOGRAPHIC DISCOVERY AND VISUAL OBSERVATIONS OF A COMET,

By E. E. BARNARD.

On the night of October 12 I made an exposure of four hours and twenty minutes on the Milky-Way near *α Aquilae*, from $6^h 40^m$ to $11^h 0^m$ Standard Pacific Time, using the Willard lens of the Crocker Observatory.

Upon developing the plate, I detected a narrow hazy streak on it, about 18′ long. This was at once suspected to be a comet, as I was familiar with the region, and had photographed the same place on Sept. 26, the plate then showing no such marking. By this time the position of the object was so close to the horizon that a search for it with the 12-inch was out of the question. The position from the plate at $9^h 0^m$ was about $\alpha = 19^h 32^m$, $\delta = +12° 50'$.

The following night, Oct. 13, as soon as the sky was dark enough, I turned the 12-inch on the spot, and after a search of a few minutes, found a faint hazy object, about a minute in diameter, and not brighter than 12½ or 13 magnitude. Observations showed this to be a new comet, and a position was hurriedly secured before the sky fogged over. A telegram announcing the discovery was at once sent out.

The trail of the comet falls very close to the middle of the plate, which is an exquisite photograph of a remarkable region. The plate used was a 10 x 8 Cramer "Lightning." From the facts that the trail is strongly marked, and the comet is visually a faint object, it would appear that its light must be mainly actinic.

In the telescope this object has no nucleus, but is gradually a little brighter in the middle. It strongly resembles in appearance Class I of short-period comets.

This is the first comet whose original discovery was made by photography.

Following are the observations so far obtained.

FILAR-MICROMETER OBSERVATIONS OF COMET *e* 1892 (*BARNARD, Oct. 12*),

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY,
BY E. E. BARNARD.

1892 Mt. Hamilton M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
d h m s			m s	′ ″	h m s	° ′ ″		
Oct. 13 7 12 29	1	3 , 5	+0 2.77	+1 14.0	19 33 57.56	+12 30 5.0	9.155	0.582
15 8 59 28	2	3 , 4	+0 10.80	−2 23.7	19 38 23.84	+11 13 35.1	9.535	0.623
16 10 21 4	3	3 , 4	−3 5.67	−5 17.2	19 40 43.59	+11 19 49.0	9.639	0.666
17 10 37 30	4	10 , 4	−1 42.76	−0 30.5	19 42 59.03	+10 57 16.2	9.655	0.683
18 6 41 29	5	3 , 4	+0 10.82	−3 12.8	19 44 55.72	+10 38 45.9	9.013	0.604
19 6 57 25	6	6 , 4	+1 20.23	+8 30.6	19 47 12.56	+10 17 26.5	9.137	0.606

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	19 33 53.25	+1.54	+12 28 41.9	+9.1	9^M comp. with Lal. 37232 $\left\{\begin{matrix}+1^m 19^s.78\\+1' 44''.9\end{matrix}\right\}$
2	19 38 11.49	+1.55	+11 45 49.6	+9.2	Grant 4886
3	19 43 47.70	+1.56	+11 24 57.0	+9.2	Grant 4910
4	19 44 40.24	+1.55	+10 57 37.6	+9.1	B.B. 4065
5	19 44 13.37	+1.53	+10 41 49.7	+9.0	Lamont 1670
6	19 45 50.81	+1.52	+10 8 47.1	+8.8	Grant 4921

On Oct. 13, 15, 16 and 18 the $\Delta\alpha$ was measured directly with micrometer.

Star No. 5 is DM. 10°4066, where it is given as $8^M.5$. Lam. gives it 10^M. My estimate was $9^M.5$. DM. and Lamont differ 1^s in R.A.

Mt. Hamilton, 1892 *October* 20.

PROPER-MOTION STARS,

BY C. L. DOOLITTLE.

In deriving the declinations of about 150 B.A.C. stars used in my latitude work of 1889–90, a number of instances of proper motion were brought to light.

In case of a few of the stars given in the following list, proper motions have been assigned by others, but with values differing materially from those found by myself. Most of them, however, are believed to be new.

In the reduction, the greater part of the published material has been employed, and in a number of instances unpublished observations have been kindly supplied from Greenwich and elsewhere.

Boss's systematic corrections have been applied to the declinations of the older catalogues, and his system of weights has generally been used. No systematic corrections have been applied to the right-ascensions, with the exception of PIAZZI, where NEWCOMB's value has been employed.

The right-ascensions are probably less reliable than the declinations.

B.A.C	Mag.	α	δ	μ	μ′	Motion in Gt Circle
		h m s	° ′ ″	s	″	″
916	6	2 51 36.14	40 31 58.85	+.0187	—.050	.219
1507	5.6	4 9 50.61	49 44 29.00	+.0058	—.060	.082
1813	6.3	5 39 29.00	68 25 52.20	—.0029	—.060	.062
1970	6.5	6 2 0.21	22 12 27.97	—.0032	—.027	.052
2083	6.2	6 22 7.25	73 17 14.14	—.0312	—.030	.134
2139	6.7	6 27 57.13	38 32 37.76	—.0000	—.027	.027
2701	6	7 59 17.64	58 36 41.57	—.0000	—.087	.087
3083	6.7	8 56 30.45	51 19 12.75	—.0101	—.073	.120
3397	6	9 50 3.23	16 0 31.60	—.0000	—.061	.061
3468	6	10 3 17.98	38 1 0.07	—.0052	—.042	.074
4403	6.5	13 3 39.13	17 30 56.29	—.0035	—.030	.058
4510	5.7	13 23 51.63	60 35 30.68	—.0101	+.031	.083
4691	7.2	14 0 53.56	31 26 53.86	.0000	—.071	.071
1728	6	11 9 21.05	12 6 22.98	.0000	—.109	.109
1825	6.2	11 29 31.88	37 10 33.38	—.0000	—.068	.068
1841	6	11 33 30.82	14 10 55.89	—.0086	+.029	[illegible]
1874	6.2	11 38 56.36	61 17 12.50	+.0115	—.012	[illegible]
5147	5.9	15 29 10.63	64 37 16.23	—.0140	+.081	.121
5210	6.5	15 39 26.97	52 45 22.17	—.0040	+.034	[illegible]
5771	5.9	17 1 46.79	0 54 16.29	—.0011	[illegible]	[illegible]
6193	6	18 8 51.63	38 44 22.91	—.0017	[illegible]	[illegible]
6656	6.5	19 19 59.51	43 8 12.98	+.0027	—.047	[illegible]
7978	6.7	22 47 28.86	39 30 11.94	[illegible]	—.034	[illegible]
8122	6.8	23 13 22.04	73 0 21.94	[illegible]	—.026	[illegible]
8365	6.5	23 58 39.29	1 11 49.87	[illegible]	[illegible]	[illegible]

Bethlehem, Pa., 1892 *September* 3.

OBSERVATIONS OF THE NEW SATELLITE OF *JUPITER*,

BY ORMOND STONE.

BARNARD's new satellite of *Jupiter* was observed with the 26-inch equatorial of the Leander McCormick Observatory, on the night of October 18. After five measures of distance had been made clouds prevented further observations. Poor seeing has also prevented seeing the satellite on any subsequent night.

Measured diameter of *Jupiter* 51″.18. Position-angle of micrometer threads 246°.4, obtained from observations of the belts of *Jupiter*.

Eastern Standard Time	Distance from		Distance from centre
h m s		″	″
11 51 38	foll. limb	36.32	61.91
11 59 28	prec. limb	86.09	60.50
12 3 52	prec. limb	88.31	62.72
12 17 29	foll. limb	37.89	63.48
12 21 50	foll. limb	38.08	63.67

NOTE ON THE PERIOD OF THE FIFTH SATELLITE OF *JUPITER*.

BY E. E. BARNARD.

For some reason, not just now apparent, the values for the periodic time of this satellite as given in my paper in *A.J.* 275, are not the values that would result from the given distances, as will be readily seen by recomputation. This erroneous value of the period has been cabled to Europe.

I have been waiting for a well-observed east elongation to get a fair value of the period, but the wind has for a long time shaken the telescope so badly during the observations, that I have not been able to secure a satisfactory elongation. From the observed east elongation of Sept. 1[illegible] Greenwich M. T., and another east [illegible] before and after elongation), Oct. [illegible] I have deduced the following: —

Period [illegible] 11 57 [illegible]

the observations before using being corrected for [illegible] and the velocity of light.

This period gives the satellite a mean distance of 112[illegible] miles.

From seven sets of measures at east elongations, the elongation distance comes out, 18″.091 at distance 5.20.

This value also corresponds to a distance of 112510 miles.

I have secured a few measures at the west elongations, and the distance seems to be 1″ less than for the east.

It is evident that considerable eccentricity exists in the orbit.

Mt. Hamilton, 1892 *October* 23.

EPHEMERIS OF COMET *e* 1892 (*BARNARD*),

[From CAMPBELL'S Elements, p. 95.]

BY MISS F. GERTRUDE WENTWORTH.

Gr. M. T.		App. α	App. δ	log Δ	Br.
1892		h m s	° ′		
Nov.	3.5	20 20 16	+5 31	0.2916	0.70
	5.5	21 12	4 57		
	7.5	29 8	4 27	.3057	.65
	9.5	33 34	3 57		
	11.5	38 0	3 27	.3190	.60
	13.5	42 24	3 0		
	15.5	46 48	2 33	.3303	.56
	17.5	46 10	2 8		
	19.5	20 55 32	+1 43	0.3151	0.51

BARNARD'S observation of Oct. 19 gives corrections, (O − C), $+10^s$ and $+0'.2$; but the corrections must, of course, now be very large, since the elements were based on single-day intervals.

The Editor deeply regrets that the want of observations of this comet has made it impossible to provide for later elements and the improved ephemeris which they would afford. The transfer of the Observatories at Albany and Washington to new sites creates a serious, even though temporary, interruption to the wonted supply of early observations.

IRREGULAR PROPER MOTION OF β *PERSEI*.

The season for the convenient observation of *Algol* and the neighboring fundamental stars, with the meridian-circle, is close at hand, and it is desired to call attention, respectfully and urgently, to the importance of such observations to confirm the irregularity in the proper motion. It is hoped that these stars will be put on the working-lists, wherever their observation is not inconsistent with other work. For convenience the list, as employed in nos. 255 and 256, is here given. The publication of any existing observations made within the last few years would also prove extremely timely and acceptable.

PLACES FOR 1875 OF β *Persei* AND ITS COMPARISON-STARS.

	h m s	° ′
γ *Andromedae*,	1 56 11	+41 43.7
β *Trianguli*,	2 2 7	34 23.7
θ *Persei*,	2 35 40	48 11.9
11 *Arietis*,	2 42 38	26 14.6
γ *Persei*,	2 55 45	53 0.9
ρ "	2 57 10	38 21.3
β *Persei*,	3 0 2	40 28.3
α "	3 15 21	49 21.9
δ "	3 34 2	47 23.1
ν "	3 36 42	42 10.9
η *Tauri*,	3 40 3	23 13.0
ζ *Persei*,	3 46 17	31 30.6
ε "	3 49 28	39 38.8
ξ "	3 50 51	35 25.8

CORRIGENDUM.

No. 276, pp. 94, 95. *for* Comet *d* 1892 (Denning), *put* Comet *d* 1892 (Brooks).

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MEASURES OF DOUBLE STARS.

BY F. P. LEAVENWORTH.

The measurement of the stars contained in this list was undertaken at the suggestion of Mr. BURNHAM, who furnished us a list of his double stars which needed re-measuring, and which were not too difficult for our telescope. To these were added a few of the more important binary stars, and several other stars.

The observations were made with the 10-inch equatorial of the Haverford College Observatory during the first part of the year 1892. The observers were WM. H. COLLINS, J. H. DENNIS, E. H. GIFFORD, G. L. JONES and F. P. LEAVENWORTH.

Σ262.

R.A. = 2h 19m. Decl. = +66° 52′.

A AND B.

	p	*s*	wt.	Mag.	Mag.	*h*	Obs'r
	°	″					
1892.069	256.9	.	2	. .	. .	5.5	C

A AND C.

	p	*s*	wt.	Mag.	Mag.	*h*	Obs'r
2.069	111.0	6.99	2	. .	. .	5.5	C

OΣ93.

R.A. = 4h 54m. Decl. = +4° 55′.

	p	*s*	wt.	Mag.	Mag.	*h*	Obs'r
1892.058	49.0	. .	4	8.5	8.5	5.2	C
.135	47.7	0.98	4	8.0	8.0	5.2	C
1892.087	48.4	0.98		8.2	8.2		

β885.

R.A. = 5h 5m. Decl. = −1° 55′.

	p	*s*	wt.	Mag.	Mag.	*h*	Obs'r
1892.135	186.5	0.72	4	8.0	9.0	5.5	C

*O*8.

R.A. = 5h 18m. Decl. = −10° 32′.

	p	*s*	wt.	Mag.	Mag.	*h*	Obs'r
1892.126	124.7	1.08	3	8.0	8.0	5.7	C
.135	122.5	1.16	3	8.3	8.3	6.0	C
1892.131	123.6	1.12		8.2	8.2		

D 4.

R.A. = 5h 29m. Decl. = −4° 55′.

	p	*s*	wt.	Mag.	Mag.	*h*	Obs'r
1892.126	214.4	1.82	3	4.0	8.0	6.5	C
.135	214.1	1.26	3	4.0	8.0	6.3	C
1892.131	214.2	1.51		4.0	8.0		

β1021.

R.A. = 6h 24m. Decl. = +28° 28′.

	p	*s*	wt.	Mag.	Mag.	*h*	Obs'r
	°	″					
1892.148	86.9	0.68	3	8.0	9.2	4.9	L
.184	85.0	0.68	2	8.2	9.5	5.2	L
1892.166	86.0	0.68	2	8.1	9.4		

β754.

R.A. = 6h 30m. Decl. = −3[illegible]° 55′.

	p	*s*	wt.	Mag.	Mag.	*h*	Obs'r
1892.146	22.8	. .	2	. .	. .	6.5	L

Very difficult.

OΣ152.

R.A. = 6h [illegible]. Decl. = +28° 22′.

	p	*s*	wt.	Mag.	Mag.	*h*	Obs'r
1892.146	34.5	0.88	2	7.5	8.5	8.1	L
.148	35.9	0.87	3	6.0	8.0	5.1	L
1892.147	35.2	0.88	2	6.8	8.2		

β195.

R.A. = 6h 37m. Decl. = −2° 7′.

A AND B.

	p	*s*	wt.	Mag.	Mag.	*h*	Obs'r
1892.146	214.2	5.63	2	7.0	11.5	5.5	L
.148	215.0	5.91	2	7.0	11.0	5.6	L
.189	214.1	5.64	2	7.5	11.0	6.4	L
.242	217.2	5.65	2	7.0	11.0	6.2	C
1892.182	215.2	5.71	2	7.1	11.1		

A AND C.

	p	*s*	wt.	Mag.	Mag.	*h*	Obs'r
1892.149	178.1	35.04	2	7.0	12.0	5.8	L

Companions very faint

β100.

R.A. = 6h 54m. Decl. = +2° 4′.

	p	*s*	wt.	Mag.	Mag.	*h*	Obs'r
1892.127	256.0	2.92	3	7.5	11.0	7.0	C

H.A H 61.

R.A. = 7h 10m. Decl. = [illegible] 25′.

	p	*s*	wt.	Mag.	Mag.	*h*	Obs'r
1892.102	311.5	2.58	. .	9.0	9.0	8.1	L
.126	311.9	2.98	3	9.0	9.0	7.7	C
1892.115	311.7	2.78		9.0	9.0		

β199.

R.A. = 7h 20m. Decl. = −20° 56′.

	p	*s*	wt.	Mag.	Mag.	*h*	Obs'r
1892.102	23.2	1.63	2	. .	. .	7.7	L

Σ1110.

R.A. = 7^{h} 28^{m}. Decl. = +32° 9′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.376	230.3	5.25	. .	. .	. .	8.0	J
.376	228.9	5.44	3	. .	. .	9.0	L
.379	230.2	5.30	. .	. .	. .	. .	J
1892.377	229.8	5.32					

β902.

R.A. = 7^{h} 52^{m}. Decl. = −10° 34′.

1892.189	240.4	. .	2	8.0	11.0	. .	L
.203	245.8	1.17	2	8.0	11.5	7.7	L
.223	245.0	. .	2	8.0	11.5	8.1	L
1892.205	243.7	1.17		8.0	11.3		

Companion very faint and difficult.

β202.

R.A. = 7^{h} 57^{m}. Decl. = −26° 53′.

1892.160	159.9	7.61	2	7.5	10.3	8.7	L
.204	161.2	7.58	2	7.0	10.0	8.0	L
.204	159.9	7.66	2	7.5	11.0	8.6	C
1892.189	160.3	7.62		7.3	10.4		

β581.

R.A. = 7^{h} 58^{m}. Decl. = +12° 38′.

½(A+B) and C.

1892.132	190.5	. .	3	8.0	11.0	8.5	C

β901.

R.A. = 8^{h} 8^{m}. Decl. = −5° 23′.

1892.116	79.2	3.68	2	8.0	11.5	7.7	L
.149	79.8	3.29	2	8.0	11.2	6.8	L
.201	81.1	3.00	2	8.0	10.5	9.4	C
.212	80.7	2.77	2	8.0	11.0	9.5	C
1892.185	80.2	3.18		8.0	11.0		

Companion very faint.

β451.

R.A. = 8^{h} 10^{m}. Decl. = −30° 29′.

1892.231	15.8	2.34	2	8.0	9.5	8.2	L
.286	17.4	2.64	2	7.5	10.0	9.0	L
1892.258	16.6	2.49		7.8	9.8		

β24.

R.A. = 8^{h} 48^{m}. Decl. = −8° 18′.

1892.132	171.7	1.02	3	7.5	8.0	9.0	C

β410.

R.A. = 9^{h} 4^{m}. Decl. = −25° 19′.

1892.209	161.3	1.86	2	7.0	9.0	9.2	L
.231	161.3	1.61	2	8.0	9.5	8.5	L
.294	160.0	1.43	2	7.0	9.0	9.6	C
1892.245	160.9	1.63		7.3	9.2		

β337.

R.A. = 9^{h} 17^{m}. Decl. = −17° 23′.

1892.146	327.2	7.93	2	7.0	10.0	9.5	C
.160	326.4	7.85	2	7.0	10.0	9.1	L
.275	326.8	7.72	2	7.0	10.5	10.3	L
1892.194	326.8	7.83		7.0	10.2		

Σ1356.

R.A. = 9^{h} 22^{m}. Decl. = +9° 35′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
	°	″					
1892.132	103.4	0.86	2	6.5	7.5	9.8	C
.146	103.5	1.11	1	6.5	7.5	11.0	C
.351	106.1	0.69	3	5.5	6.5	11.7	L
.357	104.0	0.74	3	6.0	6.8	11.0	L
.376	105.6	0.94	2	6.5	7.0	12.0	C
1892.273	104.5	0.87		6.3	7.1		

OΣ215.

R.A. = 10^{h} 10^{m}. Decl. = +18° 20′.

1892.379	212.2	0.58	3	. .	. .	11.1	L
.401	212.4	0.75	3	7.0	7.4	12.1	L
1892.390	212.3	0.66		7.0	7.4		

Σ1424.

R.A. = 10^{h} 14^{m}. Decl. = +20° 24′.

1892.310	114.6	3.41	2	. .	. .	9.8	L
.376	116.4	3.35	. .	. .	. .	8.1	J
.376	113.2	3.19	3	. .	. .	8.2	L
.379	112.6	3.46	. .	. .	. .	9.0	J
.464	114.6	3.62	. .	. .	. .	10.4	G
1892.383	114.3	3.47					

β219.

R.A. = 10^{h} 16^{m}. Decl. = −21° 55′.

1892.146	187.2	2.13	2	7.0	9.0	10.0	C
.195	187.8	2.17	2	7.0	9.5	11.2	L
.209	192.5	2.14	2	7.0	9.0	9.5	L
.294	185.0	1.80	1	7.0	9.0	9.6	C
1892.211	188.1	2.11		7.0	9.1		

β411.

R.A. = 10^{h} 30^{m}. Decl. = −26° 3′.

1892.286	290.4	1.17	1	7.0	8.5	. .	L
.294	291.8	1.63	1	6.5	8.5	10.1	C
.313	289.3	1.03	2	. .	. .	10.5	L
.330	291.1	1.34	1	. .	. .	10.5	C
1892.306	290.6	1.29		6.8	8.5		

Σ1457.

R.A. = 10^{h} 32^{m}. Decl. = +6° 21′.

1892.132	320.3	1.39	2	7.5	8.0	10.5	C
.146	319.8	1.14	2	7.0	8.0	11.5	C
1892.138	320.0	1.26		7.2	8.0		

β915.

R.A. = 10^{h} 43^{m}. Decl. = +24° 55′.

1892.286	239.1	0.8*E*	1	9.0	9.0	. .	L
.294	234.7	0.6*E*	1	. .	. .	11.0	L
.302	230.1	0.6*E*	2	. .	. .	. .	L
.313	226.0	0.8*E*	2	. .	. .	11.0	L
1892.299	232.5	0.7		9.0	9.0		

E estimated. Faint and difficult.

Σ1523.

R.A. = 11h 12m. Decl. = +32° 13′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.447	197.0	1.71	3	4.5	5.5	13.2	L
.453	196.1	1.49	3	5.0	5.5	13.3	L
1892.450	196.6	1.60		4.8	5.5		

OΣ234.

R.A. = 11h 24m. Decl. = +41° 57′.

1892.453	136.5	0.4*E*	1	. .	. .	. .	L

E estimated. Very difficult.

OΣ235.

R.A. = 11h 26m. Decl. = +61° 45′.

1892.447	84.2	0.82	2	5.0	7.0	13.5	L
.453	86.6	0.78	3	5.5	7.0	13.7	L
1892.450	85.4	0.80		5.2	7.0	13.6	

β917.

R.A. = 11h 37m. Decl. = +11° 22′.

1892.146	173.6	2.98	2	7.5	11.0	10.3	C
.204	175.5	3.02	2	8.0	11.0	10.3	C
.242	171.4	3.39	. .	. .	. .	11.5	D
.291	178.3	3.38	2	8.0	11.0	11.9	L
1892.241	175.4	3.19		7.8	11.0		

Σ1620.

R.A. = 12h 10m. Decl. = +9° 46′.

1892.330	81.5	1.93	2	8.5	10.0	12.1	L

β920.

R.A. = 12h 10m. Decl. = 22° 41′.

1892.313	251.1	0.77	3	6.5	7.5	12.5	L
.313	252.6	. .	.	. .	. .	12.8	J
.351	218.7	0.8*E*	1	. .	. .	12.7	L
.357	246.2	0.86	1	7.0	8.0	11.7	L
.398	251.0	0.80	2	6.0	8.0	12.1	L
1892.346	250.5	0.81		6.5	7.8		

E estimated.

β921.

R.A. = 12h 12m. Decl. = −23° 21′.

1892.321	221.1	. .	1	7.2	12.0	. .	L
.330	218.5	3.05	2	7.0	12.0	12.8	L
.351	217.0	2.93	2	7.0	12.0	12.2	L
.357	217.1	2.86	2	7.0	12.0	12.0	L
1892.315	218.5	2.95		7.0	12.0		

Companion very faint and difficult.

Σ1670.

R.A. = 12h 36m. Decl. = [illegible] 0° 47′.

1892.417	152.6	5.72	3	. .	. .	12.6	L
.436	151.9	5.62	2	. .	. .	11.0	D
1892.427	152.2	5.67					

β926.

R.A. = 12h 52m. Decl. = [illegible] 24′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.302	268.1	2.34	2	8.0	12.0	[illegible]	L
.230	267.8	2.13	2	8.0	11.5	13.2	L
.376	273.7	2.23	1	8.5	11.5	12.6	C
1892.336	269.9	2.23		8.2	11.7		

β112.

R.A. = 12h 55m. Decl. = +19° 1

B AND C.

1892.302	293.3	1.95	2	9.3	9.8	12.6	L
.313	287.9	1.91	2	9.0	10.0	13.8	L
.351	292.0	1.83	2	9.0	9.5	13.2	L
1892.322	291.1	1.90		9.1	9.8		

β927.

R.A. = 12h 57m. Decl. = −5° 53′.

1892.291	289.2	4.52	2	8.0	10.0	12.5	L
.302	292.2	1.38	2	8.0	10.0	13.5	L
.351	290.2	1.35	2	8.5	10.0	13.6	L
1892.316	290.5	1.42		8.2	10.0	13.6	

β928.

R.A. = 12h 57m. Decl. = −5° 57′.

1892.376	305.8	. .	1	8.0	9.0	. .	C

Σ1728.

R.A. = 13h 4m. Decl. = +18° 16′.

1892.357	11.9	0.17	2	5.8	6.2	14.2	L
.379	11.5	0.5*E*	2	. .	. .	13.1	L
1892.368	11.7	0.48		5.8	6.2		

E estimated.

β610.

R.A. = 13h 17m. Decl. = −20° 19′.

1892.357	17.6	3.81	2	7.0	11.8	13.0	L
.379	18.5	4.04	1	7.0	12.0	12.9	L
.398	19.4	3.61	2	7.2	11.5	13.0	L
1892.378	18.5	3.82		7.1	11.8		

β460.

R.A. = 13h 19m. Decl. = [illegible]

1892.357	37.1	2.37	2	8.0	10.5	11.5	L
.379	32.0	2.04	1	8.0	10.5	13.2	L
.398	35.0	2.37	2	8.0	10.5	12.7	L
1892.378	34.8	2.26		8.0	10.4		

β30.

R.A. = 13h 52m. Decl. = +2[illegible]

1892.173	197.9	. .	1	8.0	12.0	[illegible]	L
.302	199.8	8.10	2	8.0	11.0	14.3	L
.321	200.9	8.07	2	7.7	10.5	13.0	L
.357	199.9	8.10	2	8.1	10.8	13.4	L
1892.288	199.6	8.29		8.0	11.0		

β938.

R.A. = 13^h 59^m. Decl. = −26° 0′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
		″					
1892.409	301.0	0.6*E*	1	. .	. .	11.6	L
.414	299.9	0.60	3	7.5	7.7	11.0	L
.417	294.7	0.65	3	. .	. .	11.2	L
.420	297.8	. .	2	. .	. .	11.4	L
1892.415	299.4	0.62		7.5	7.7		

E estimated.

β615.

R.A. = 14^h 18^m. Decl. = +49° 4′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.321	236.0	1.97	2	8.2	9.5	13.5	L
.362	235.7	2.76	2	8.5	9.8	11.9	L
.420	233.2	2.82	2	8.5	10.0	13.4	L
1892.368	235.0	2.52		8.4	9.8		

Σ1888.

R.A. = 14^h 46^m. Decl. = +19° 38′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.242	240.7	3.16	3	. .	. .	13.9	L
.330	242.1	3.14	3	. .	. .	17.7	L
.401	237.2	2.94	2	. .	. .	17.0	L
1892.321	240.0	3.08					

β942.

R.A. = 14^h 47^m. Decl. +0° 2′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.343	189.8	1.0 *E*	1	. .	. .	. .	L
.357	190.7	1.17	2	9.0	9.3	11.7	L
.398	197.1	1.13	2	9.0	9.0	15.0	L
.409	182.3	0.83	2	9.2	9.2	11.8	L
.411	189.2	0.99	3	9.2	9.2	11.7	L
1892.384	189.8	1.02		9.1	9.2		

E estimated; difficult.

β419.

R.A. = 14^h 59^m. Decl. = −6° 33′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.343	306.8	1.49	3	8.0	8.5	11.8	L
.351	308.2	1.43	3	8.0	8.4	15.0	L
.362	306.5	1.50	2	8.0	8.5	15.4	L
1892.352	307.1	1.47		8.0	8.5		

Σ1909.

R.A. = 15^h 0^m. Decl = +48° 5′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.362	241.2	1.53	2	5.0	6.3	14.4	L
.458	241.9	1.56	4	5.0	5.5	13.2	L
1892.410	241.6	1.54		5.0	5.9		

β349.

R.A. = 15^h 3^m. Decl. = +2° 9′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.395	35.1	3.75	2	8.0	11.8	15.2	L
.398	37.3	3.86	2	8.0	12.0	15.2	L
1892.396	36.2	3.80		8.0	11.9		

Companion very difficult.

β809.

R.A. = 15^h 3^m. Decl. = −22° 16′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
	°	″					
1892.395	119.7	1.60	2	8.2	10.2	15.5	L
.409	118.7	1.67	2	8.0	10.0	15.1	L
1892.402	119.2	1.64		8.1	10.1		

β350.

R.A. = 15^h 8^m. Decl. = −27° 9′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.409	160.5	1.13	2	7.0	8.3	15.5	L
.414	160.0	1.17	3	7.4	8.6	15.2	L
1892.412	160.2	1.15		7.2	8.4		

β352.

R.A. = 15^h 11^m. Decl. = −26° 33′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.401	68.4	13.96	2	8.0	9.3	15.0	L
.414	68.2	13.91	3	8.2	9.0	15.4	L
1892.407	68.3	13.95		8.1	9.2		

F. P. L.

R.A. = 15^h 13^m. Decl. = −26° 35′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.357	29.3	17.18	2	8.4	9.5	15.2	L
.404	30.0	16.84	3	7.8	9.5	15.3	L
1892.379	29.6	17.01		8.1	9.5		

Observed for β352.

β228.

R.A. = 15^h 13^m. Decl. = −23° 50′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.395	328.1	0.93	2	7.2	8.0	15.8	L
.414	327.0	1.04	3	7.3	8.3	15.7	L
1892.405	327.6	0.98		7.2	8.4		

β353.

R.A. = 15^h 14^m. Decl. = +85° 57′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.417	295.5	3.62	2	9.4	9.8	18.7	L
.423	295.7	3.74	2	9.5	10.0	14.3	C
1892.420	295.6	3.68		9.4	9.9		

Σ1937.

R.A. = 15^h 18^m. Decl. = +30° 43′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.422	231.7	0.79	2	. .	. .	13.0	C
.477	228.5	0.66	2	. .	. .	14.4	L
1892.450	230.1	0.72					

Σ1938.

R.A. = 15^h 20^m. Decl. = +37° 46′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.422	92.6	0.82	3	. .	. .	13.4	C

β33.

R.A. = 15^h 25^m. Decl. = −12° 35′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.401	41.8	3.17	2	7.8	10.5	15.7	L
.409	42.4	2.98	2	7.8	10.2	15.8	L
1892.405	42.1	3.08		7.8	10.4		

OΣ298.

R.A. = 15h 32m. Decl. = +40° 13'.

	p	s	wt.	Mag.	Mag.	h	Obs'r
	°	"					
1892.422	169.9	0.82	2	. .	. .	13.7	C

β620.

R.A. = 15h 39m. Decl. = −27° 41'.

A and B.

1892.414	165.5	0.65	2	7.0	7.6	16.0	L

A and C.

1892.414	215.4	50.53	3	7.0	10.0	16.1	L

β240.

R.A. = 15h 39m. Decl. = +4° 24'.

A and B.

1892.354	135.4	2.29	2	8.5	9.8	16.2	L
.376	136.6	2.22	2	8.3	9.6	17.4	L
.379	133.1	2.30	2	8.5	10.0	15.7	L
1892.700	135.0	2.27		8.4	9.8		

A and C.

1892.354	39.7	28.44	2	. .	12.0	16.5	L
.379	40.8	28.22	2	. .	. .	15.0	L
1892.366	40.2	28.33			12.0		

β415.

R.A. = 15h 45m. Decl. = +65° 57'.

A and B.

1892.417	334.6	12.82	3	8.5	11.0	17.8	L
.422	336.1	12.72	3	8.0	10.0	11.8	C
1892.420	335.4	12.77		8.2	10.5		

A and C.

1892.417	358.5	29.12	3	. .	11.0	17.9	L
.422	358.1	29.33	3	. .	10.2	11.8	C
1892.420	358.3	29.22			10.6		

β36.

R.A. = 15h 46m. Decl. = −24° 58'.

1892.376	277.3	2.88	2	6.0	7.7	17.2	L
.395	278.2	2.84	2	5.6	7.6	16.1	L
1892.386	277.8	2.86		5.8	7.6		

β37.

R.A. = 15h 55m. Decl. = −24° 15'.

1892.409	43.3	3.30	2	8.8	9.4	10.2	L
.444	41.0	2.84	3	8.1	10.0	16.5	L
.434	42.9	3.16	2	8.6	9.6	16.1	L
1892.416	43.4	3.09		8.6	9.7		

β918.

R.A. = 15h 59m. Decl. = −5° 58'.

A and B.

1892.376	151.4	. .	3	. .	. .	17.7	L
.395	149.3	1.43	2	6.8	9.5	16.4	L
.409	148.7	1.51	3	7.4	9.2	16.5	L
.417	147.8	1.68	3	. .	. .	17.1	L
1892.399	149.3	1.54		7.1	9.1		

A and C.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.409	234.9	29.15	2	. .	10.4	16.7	L
.417	234.6	28.95	3	. .	. .	17.1	L
1892.413	234.8	29.05			10.4		

A and D.

1892.409	194.8	52.66	2	. .	10.8	16.8	L
.417	195.0	52.78	3	. .	. .	17.1	L
1892.413	194.9	52.72			10.8		

β123.

R.A. = 16h 48m. Decl. = −21° 51'.

1892.444	206.6	1.57	2	8.4	8.8	16.6	L
.477	201.7	1.55	2	8.2	9.0	17.1	L
.518	203.3	1.60	2	8.5	8.5	17.6	L
1892.480	203.9	1.57		8.4	8.8		

β44.

R.A. = 17h 9m. Decl. = +28° 58'.

1892.453	20.2	5.65	3	8.0	9.5	15.2	C
.477	18.1	. .	2	. .	. .	18.2	L
.516	19.3	5.44	2	8.8	9.5	20.0	L
1892.482	19.2	5.54		8.4	9.5		

β242.

R.A. = 17h 17m. Decl. = −[illegible] 35'.

A and B.

1892.453	67.7	1.04	3	8.0	8.0	16.5	C
.477	72.8	1.00	3	8.2	8.8	17.4	L
.516	72.1	0.92	3	8.3	9.3	19.0	L
1892.482	70.9	0.99		8.2	8.7		

½ A+B and C.

1892.477	62.0	9.04	3	. .	11.0	17.6	L

½ A+B and D.

1892.477	64.8	17.83	3	. .	10.0	17.8	L

β46.

R.A. = 17h 18m. Decl. = +[illegible]

1892.453	201.1	1.71	3	7.5	10.5	16.7	C
.477	200.9	. .	2	8.0	12.0	18.0	L
.518	203.9	2.15	2	8.0	10.5	17.8	L
.532	201.0	1.84	3	8.0	[illegible]	17.3	L
1892.495	202.6	1.91		7.9	[illegible]		

Σ2272.

R.A. = 17h 59m. Decl. = [illegible]

1892.444	320.5	2.36	2	. .	. .	[illegible]	C

β244.

R.A. = 18h 1m. Decl. = [illegible]

1892.532	257.6	2.11	2	8.0	[illegible]	[illegible]	L
.548	258.2	1.98	2	8.0	[illegible]	[illegible]	L
1892.540	257.9	2.04		8.0	[illegible]		

β245.

R. A. = $18^h\ 2^m$. Decl. = $30°\ 45'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
	°	$''$					
1892.518	253.8	3.99	2	6.2	8.8	18.3	L
.521	252.8	3.97	1	6.5	9.0	19.1	L
1892.521	253.3	3.98		6.4	8.9		

β132.

R. A. = $18^h\ 4^m$. Decl. = $-19°\ 52'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.518	226.4	0.83	2	7.2	7.3	18.1	L
.524	229.3	0.95	2	7.3	7.3	18.9	L
1892.521	227.8	0.89		7.2	7.3		

F. P. L.

R. A. = $18^h\ 5^m$. Decl. = $-15°\ 42'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.548	27.2	3.61	2	8.0	11.3	18.1	L
.568	25.6	3.54	2	8.2	11.2	18.2	L
1892.558	26.1	3.58		8.1	11.2		

F. P. L.

R. A. = $18^h\ 6^m$. Decl. = $-15°\ 24'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.518	276.7	3.66	2	8.1	11.0	19.5	L
.521	276.3	. .	1	8.0	12.0	. .	L
.548	281.0	3.95	2	8.0	12.0	17.6	L
1892.530	278.0	3.80		8.1	11.7		

β292.

R. A. = $18^h\ 7^m$. Decl. = $-21°\ 5'$.

A and B.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.551	258.0	17.18	1	4.0	11.0	17.7	L
.562	259.2	17.06	3	5.0	11.5	17.6	L
1892.558	258.6	17.12		4.5	11.2		

A and D.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.562	312.8	48.63	2	. .	9.5	17.8	L

A and E.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.562	116.0	19.96	2	. .	9.7	17.9	L

β131.

R. A. = $18^h\ 7^m$. Decl. = $-15°\ 38'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.518	279.9	2.76	2	8.0	9.5	19.8	L
.548	280.4	2.77	2	8.0	9.5	17.9	L
1892.533	280.2	2.76		8.0	9.5		

β48.

R. A. = $18^h\ 14^m$. Decl. = $-19°\ 43'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.562	0.2	2.17	2	8.2	10.2	18.2	L

β49.

R. A. = $18^h\ 17^m$. Decl. = $-19°\ 37'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.532	46.1	8.63	2	8.0	10.8	18.5	L
.548	15.3	8.30	2	8.4	11.0	18.5	L
.562	46.7	8.25	3	8.5	10.3	19.1	L
1892.548	16.0	8.39		8.3	10.7		

β1128.

R. A. = $18^h\ 23^m$. Decl. = $-33°\ 1'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.562	201.0	. .	2	6.0	11.0	19.4	L

β135.

R. A. = $18^h\ 31^m$. Decl. = $-11°\ 6'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.532	187.1	. .	1	8.0	12.0	18.8	L

β136.

R. A. = $18^h\ 37^m$. Decl. = $+5°\ 37'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.532	8.0	4.61	2	9.0	9.2	19.0	L
.554	7.4	4.72	2	9.0	9.1	18.2	L
1892.543	7.7	4.68		9.0	9.2		

β969.

R. A. = $18^h\ 44^m$. Decl. = $-8°\ 3'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.553	238.4	. .	1	7.5	12.0	18.7	L
.562	237.7	11.82	2	7.2	11.5	19.6	L
.568	238.8	11.76	2	7.8	11.5	18.5	L
1892.561	238.3	11.79		7.5	11.6		

β467.

R. A. = $19^h\ 30^m$. Decl. = $-21°\ 49'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.518	131.2	3.13	2	8.0	11.0	20.0	L

β829.

R. A. = $19^h\ 43^m$. Decl. = $+5°\ 27'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.516	307.8	0.83	2	8.0	8.8	20.7	L
.518	310.1	0.76	2	8.0	8.4	20.2	L
1892.517	319.0	0.80		8.0	8.6		

β361.

R. A. = $19^h\ 45^m$. Decl. = $+22°\ 22'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.516	349.2	3.83	2	9.0	9.2	20.9	L
.518	350.8	4.09	3	9.0	9.0	20.5	L
1892.517	350.0	3.96		9.0	9.1		

β266.

R. A. = $19^h\ 52^m$. Decl. = $+11°\ 5'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.568	167.0	15.94	2	8.0	11.0	19.8	L

β428.

R. A. = $20^h\ 1^m$. Decl. = $+12°\ 36'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.568	351.4	0.61	2	7.5	8.8	20.0	L

F. P. L.

R. A. = $20^h\ 48^m$. Decl. = $-11°\ 20'$.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1892.562	298.0	. .	2	8.5	9.8	20.3	L

University of Minnesota, 1892 *Oct.* 5.

NEW ELEMENTS AND EPHEMERIS OF COMET *e* 1892. (*BARNARD, Oct. 12.*)

BY W. W. CAMPBELL.

From Mr. BARNARD's observations of October 13, 19 and and 25, I have computed new elements of this comet, as follows:

$$T = \text{Gr. M.T. 1892 Dec. } 2^{d}.5977.$$

$$\left.\begin{aligned}\omega &= 165^\circ\ 41'.51\\ \Omega &= 201\ \ 19.31\\ i &= \ 33\ \ 35.93\end{aligned}\right\}\ 1892.0$$

$$\log q = 0.18528$$

Residuals (Obs.—Comp.)

$$\cos\beta' \cdot l\lambda' = +0'.64$$
$$l\beta' = \ \ 0.00$$

The residual in longitude is large, but another approximation to a parabolic orbit does not reduce it. This fact, taken in connection with the direct motion, and the fairly small inclination, points strongly to an elliptic orbit. However, the first observation depends upon a LALANDE star, and the character of the orbit cannot now be decided.

The original elements, distributed by telegraph, represented the observations upon which they were based very well; though, as stated in the telegrams, they were subject to some uncertainty. The new elements differ considerably from the old ones, and are themselves liable to considerable change, since a small change in the observed data would produce a large variation in some of the elements.

I am indebted to Mr. S. D. TOWNLEY for assistance in computing the ephemeris.

Mt. Hamilton, 1892 *Oct.* 27.

EPHEMERIS FOR GREENWICH MEAN TIME.

1892	App. α	App. δ	log r	log Δ	Br.
	h m	° ′			
Nov. 7.5	20 34.0	+3 7.5	0.1962	0.1107	1.10
9.5	20 40.0	2 29.0			
11.5	20 46.0	1 51.5	0.1931	0.1142	1.09
13.5	20 52.2	1 15.0			
15.5	20 58.1	0 39.1	0.1901	0.1183	1.08
17.5	21 4.7	+0 5.2			
19.5	21 11.0	—0 28.3	0.1883	0.1240	1.06
21.5	21 17.5	1 0.4			
23.5	21 24.0	1 31.3	0.1868	0.1288	1.05
25.5	21 30.6	2 0.9			
27.5	21 37.2	2 29.2	0.1857	0.1348	1.02
29.5	21 43.8	2 56.1			
Dec. 1.5	21 50.5	—3 21.7	0.1853	0.1415	0.99

OBSERVATIONS OF THE FIFTH SATELLITE OF *JUPITER*, AT THE HALSTED OBSERVATORY, PRINCETON, N.J., BY MR. T. REED.

(Communicated by Professor YOUNG.)

The new satellite has been observed here with the 23-inch equatorial by Mr. REED on several occasions:—first on Oct. 10, also on the 11th and 13th, and since then on the 28th and 29th. I have delayed publication of the observations in hopes that we might be able to obtain satisfactory micrometer measures sufficient to determine the time of an elongation with accuracy, but thus far Mr. REED has not succeeded in getting any complete set, embracing both sides of an elongation. The micrometer is not yet suitably fitted up for such work, and the weather has been unfavorable.

On Oct. 10 the satellite was better seen than on any other evening, and the three following measures were made of its distance from the planet's eastern limb, viz: 36″.56 at 18h 4m Gr. M.T.; 36″.12 at 18h 11m, and 34″.25 at 18h 19m. Assuming 37″.88 as the elongation-distance of the satellite from the limb at this date, in accordance with BARNARD's measures of Sept. 10–11, (given in this Journal No. 275) corrected for change of the planet's distance, the time of elongation comes out 17h 57m, Gr. M.T.

On Sept. 11, 13 and 28 no measures could be made. On the 29th a single not very satisfactory measure gave the distance 34″.78 at 16h 55m Gr. M.T., corresponding to an elongation-time of 16h 21m. Of course these times of elongation cannot be regarded as well determined, and the error may easily be fully five minutes: each is more than ten minutes later than the time *estimated* by Mr. REED before computing it from the measures; taking them as they stand, however, and combining them with the observations of BARNARD above quoted, they give 11h 57m 23s for the sidereal period of the satellite, with an error probably less than 10 seconds.

The satellite would have been found some time earlier, if we had not been misled by the erroneous period (11h 36m) given in Mr. BARNARD's first communication. On Oct. 10 it was detected up near the *eastern* elongation, when according to the published period it should have been near the western.

Mr. REED reports it as not a very difficult object, and thinks it might be seen with instruments of considerably smaller aperture than 23 inches. On Oct. 10 it was shown to a number of visitors, who all saw it easily.

I have been prevented by other engagements from taking any personal part in the observations.

Princeton, N.J., 1892 *Nov.* 5.

C. A. YOUNG.

FILAR MICROMETER OBSERVATION OF COMET *e* 1892 (*BARNARD, Oct. 12*),

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY,

BY E. E. BARNARD.

1892 Mt. Hamilton M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
Oct. 25 $7^h\,50^m\,31^s$	8	1 , 3	$-0^m\,13^s.23$	$-2'\,0''.2$	$20^h\,1^m\,51^s.01$	$+8°\,5'\,5''.9$	9.398	0.647

Δα was measured directly.

Mean Place for 1892.0 of Comparison-Star.

*	α	Red. to app. place	δ	Red. to app. place	Authority
8	$20^h\,2^m\,2^s.72$	$+1^s.55$	$+8°\,6'\,59''.3$	$+6''.8$	B.B. VI, 4338.

NEW ASTEROID.

Dr. Kreutz has sent the following communication from Mr. Berberich, at Berlin, October 22.

1892 *K*. New planet, Wolf.

Oct. 20, $10^h\,25^m.0$ Heidelberg M.T. $\alpha = 34°\,39'$, $\delta = +18°\,8'$. Daily motion, $-12'$ in α, and $7'$ southward.

COMET *f* 1892.

The telegraph announces the discovery of a bright comet by Holmes Nov. 6.531 Greenw. M.T., in right-ascension $0^h\,16^m\,18^s$, and declination $+38°\,32'$.

An observation by Prof. Barnard, telegraphed from the Lick Observatory, gives

$$1892 \text{ Nov. } 8.6877 \text{ Gr. M.T.} \qquad \alpha = 0^h\,46^m\,16^s.3, \qquad \delta = +38°\,23'\,5''.$$

Father Searle, who obtained observations Nov. 10 and 11, writes that it is visible to the naked eye, circular, about 7′ in diameter, very diffuse, and without any tail. It is nearly as bright as the great nebula in *Andromeda*, close by, and has very sharply defined margins, especially opposite to the jets, which are plainly issuing from one side.

CORRECTIONS TO THE *URANOMETRIA ARGENTINA*.

Mr. T. W. Backhouse, of Sunderland, sends a list of corrigenda in the *Uranometria Argentina*, additional to those previously made public. Among these are the following:

Page	No.	Column	*for*	*put*
25	226	W. Bessel	819 9	819 7
30	456	Declination	16	6
33	599	Durchmusterung	4226	4426
36	718	W. Bessel	928 7	926.7 8½
145	21	Catálogo	B 5027	B.5026
150	61	Magnitud	6.9	5.9
154	271	Catálogo	B.4682,4683	B.4642,4643
172	106	"	Ll.18783	Ll.14783

264 no. 57. Erase the allusion to Behrmann's Catalogue.

333 line 8 from below, *for* Ll. 14830 *put* Ll. 14834.

The following corrections were communicated in the year 1887, by Prof. H. M. Paul.

Page 74. The first clause in the south boundary of *Hydra* should read:

"11 0′ as far as $8^h\,22^m$; this meridian southward to 16° 0′;"

Page 87. Line 7 from end of *Eridanus for R put S*, in both columns.

Page 149. λ *Pictoris* *for* B.1585 *put* L.1585.

Page 221. *Aquila*, no. 78 *for* *v* *put* *υ*.

Page 222. π *Orionis* *for* L.9057 *put* Ll.9057.

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OBSERVATIONS OF STARS RECENTLY ANNOUNCED TO BE VARIABLE.

BY PAUL S. YENDELL.

The observations here given are a part of a line of work, in the examination of a number of stars whose variability has been announced in recent volumes of the *Astronomische Nachrichten*, which was undertaken late in the year 1891, and a part of which, resulting in the confirmation of the variability of the star *R Trianguli*, has already been published in the current volume of this Journal.

The instrument used has been in all cases my 4¼-inch Clacey refractor, with an Airy eyepiece giving a power of 30, and a field of rather more than two degrees, with very sharp and brilliant definition, showing, on favorable nights, stars down to the limit of the theoretical capacity of the objective; as an instrument for observing variable stars, I consider it to be perfect as far as its capacity extends.

The **Argelander** method has been followed in this work; the magnitudes, except where expressly stated to be eye-estimates, being deduced by careful comparison with the magnitudes assigned to the comparison-stars from the light-scales formed from all the observations in each case.

I.

$\alpha = 1^{\rm h}\ 49^{\rm m}\ 59^{\rm s}.7; \quad \delta = +54°\ 7'.0\ (1855).$

The variability of this star, which is DM. 54 431, was announced by Mrs. **Fleming** in the *Astronomische Nachrichten*, Vol. CXXVI, p. 165, where she gives measures from seven photographic plates giving 9$^{\rm M}$.0 to 11$^{\rm M}$.4.

I began to watch the star, 1891 Nov. 30, when its brightness was estimated at 10$^{\rm M}$.5; from this date until the present, I have had it under observation, with the exception of the interval between 1892 March 16 and Aug. 15, when its position near the northern horizon rendered observation practically impossible from the reflection of the city lights. Upon being looked for on the latter date, its variation was at once apparent, the star being comparatively bright, and quite conspicuous in the field of the telescope; its light was estimated at 8$^{\rm M}$.6; on Aug. 21st a further rise of four-tenths of a magnitude showed itself; from this date the star has fallen off steadily and rather rapidly, and its light when last observed, Oct. 19, was 9$^{\rm M}$.7. The date of maximum may be set at 1892 Aug. 21.

The observed magnitudes are as follows:

		M
1891 Nov.	30,	10.5
Dec.	5,	10.8
	28,	10.5
1892 Jan.	16,	not seen; limit <11$^{\rm M}$.0
*Feb.	1,	11.0
Mar.	16,	not seen; limit 11$^{\rm M}$.0 ±
Aug.	15,	8.6
	21,	8.2
	29,	8.3
Sept.	2,	8.4
	6,	8.4
	10,	8.5
1892 Sept.	13,	8.6
	17,	8.7
	20,	8.6
	23,	8.7
	26,	8.8
	29,	8.8
Oct.	8,	8.8
	10,	9.2
	12,	9.3
	14,	9.4
	19,	9.7

* Eye-estimates.

The star's light is not sensibly red to my eye.

II.

$\alpha = 1^{\rm h}\ 52^{\rm m}.1; \quad \delta = +56°\ 2'\ (1855).$

This star is not in the *Durchmusterung*. Mrs. **Fleming** (*Astron. Nachr.* Vol. CXXVI, p. 165) calls it variable, and gives seven measures from photographic plates, from less than 13$^{\rm M}$.2 to 9$^{\rm M}$.2.

From 1891 Nov. 30 to the present time, I have ten recorded observations, besides looking for the star on sundry occasions when no record was made, and have never seen anything brighter than 11 magnitude in its place.

The notes of my observations are as follows:

1891 Nov. 30. Not seen; **Knott's** comp. star *f*, for *U Geminorum*, rated by him 11$^{\rm M}$.2*, well seen, though at lower altitude.

1891 Dec. 5. Not seen; limit <11$^{\rm M}$.0.

Dec. 28. 11$^{\rm M}$.5 star in place? **Knott's** comp. stars for *U Geminorum*, *f*, 11$^{\rm M}$.2, *g*, 12$^{\rm M}$.3, and *h*, 12$^{\rm M}$.5, seen.

1892 Jan. 16. Not seen; limit 11$^{\rm M}$.0 ±.
Mar. 16. " " " "
Aug. 17. " " " "
Sept. 17. " " " <11$^{\rm M}$.0
Sept. 20. " " " 11$^{\rm M}$.0 ±
Oct. 10. " " " "
Oct. 19. " " " "

* **Baxendell's** and **Knott's** estimates

Taken in connection with the measures given, *loc. cit.*, these observations seem to confirm the star's variability.

III.

$\alpha = 3^{h}\ 29^{m}\ 23^{s}$; $\delta = +62°\ 10'.1$ (1855).

This star is DM. 62°596 = Espin-Birmingham 75; very red. *Astron. Nachr.* no. 3025, Mrs. Fleming gives a long list of photo-plate magnitudes (reduced to visual by a correction of $-3^{M}.6$) ranging from $7^{M}.3$ to $8^{M}.8$. Krueger's G.A.G. estimates were $6^{M}.8$, $7^{M}.5$, $7^{M}.6$ — fiery red.

I have eight observations, covering a period of ten months; they seem to me to give no evidence of variation, being, in view of the star's strong color, very accordant, with the exception of those of 1892 Mar. 29 and April 19, both of which depend on single-star comparisons, and are the only ones in the series in which this is the case.

The observed magnitudes are as follows:

	M	
1891 Dec. 3,	8.7	very red
5,	8.8	"
28,	8.5	"
1892 Jan. 16,	8.6	"
Mar. 5,	8.5	"
29,	7.9	"
Apr. 19,	7.9	"
Oct. 19,	8.8	"

IV.

$\alpha = 5^{h}\ 25^{m}\ 22^{s}$; $\delta = +68°\ 12'.5$ (1855.)

The star is DM. 68°398 = Espin-Birmingham 116.

Espin (*Astron. Nachr.* Vol. CXXVI, p. 359), says probably variable. Schönfeld (Vol. CXXVII, p. 89), gives DM. observations as follows:

Z. 1764; Sch. 1858 Nov. 12, $9^{M}.10$;
1831; Sch. 1859 Mar. 9, $9^{M}.0$

I found the star $9^{M}.1$ on 1891 Dec. 1; it declined rapidly until 1892 Feb. 18, when my note reads "$12^{M}.0 \pm$, very difficult to hold" (with 1¼ inches): it seems to have passed its minimum about this time, as the next observation, Mar. 5, shows a rise to $9^{M}.9$, and further observations up to Oct. 19 indicate a maximum of about $8^{M}.5$, 1892 Aug. 21. The individual observations are as follows:

	M		M
1891 Dec. 1,	9.1	1892 May 17,	9.3
5,	9.3	23,	9.0
28,	9.8	27,	9.1
1892 Jan. 31,	10.6	June 15,	8.7
Feb. 18,	12.0 ± *	20,	8.8
Mar. 5,	9.9	Aug. 17,	8.6
15,	9.7	21,	8.5
25,	9.3	Sept. 15,	8.6
29,	9.2	29,	8.6
April 6,	9.1	Oct. 10,	9.1
19,	9.2	13,	9.1
23,	9.3	14,	8.7
30,	9.3	18,	9.0
May 7,	9.2	19,	9.1

* Eye-estimate.

The star shows no marked color, to my eye.

V.

$\alpha = 5^{h}\ 32^{m}\ 37^{s}$; $\delta = +31°\ 57'$ (1855).

Espin (*Astron. Nachr.* Vol. CXXVI, p. 327) says this star is variable, finding it $8^{M}.5$, though not in the *Durchmusterung.*

Schönfeld shows that it was missed on four dates in the DM. zones, although it apparently ought to have been seen.

I have eight observations, which appear to confirm the star's variability, as follows:

1891 Dec. 1,	No star seen in place; limit $< 11^{M}.0$	
5,	" " " " $11^{M}.0$	
26,	" " " " $12^{M}.0$	
1892 Mar. 29,	$9^{M}.2$	
Apr. 16,	$9^{M}.7$	
19,	$9^{M}.8$	
Oct 18,	Not seen; limit $10^{M}.0 \pm$	hazy
19,	Not seen; limit $< 11^{M}.0$	clear

VI.

$\alpha = 16^{h}\ 39^{m}\ 19^{s}.1$; $\delta = +55°\ 11'.8$ (1855).

DM. 55°1870. Espin (Wolsingham Cir. No. 32, *Astron. Nachr.* Vol. CXXIX, p. 311) says it was found, 1892 April 26, 29; $7^{M}.5$, $7^{M}.7$. Its DM. magnitude is $9^{M}.2$.

My observations give

	M		M
1892 Aug. 13,	8.3	1892 Sept. 9,	8.7
16,	8.2	14,	8.8
23,	8.1	Oct. 12,	8.5

The star is not noticeably red to my eye. The evidence seems to favor its variability.

VII.

$\alpha = 21^{h}\ 35^{m}\ 15^{s}.8$; $\delta = +53°\ 10'$ (1855).

This star is DM. 53°2684. Espin (*Astron. Nachr* Vol. CXXVI, p. 111) says it is probably variable. In the spring of 1890 it was $7^{M}.5$–$8^{M}.0$, on 1890 Nov. 15, it was $9^{M}.0$.

Its DM. magnitude is $8^{M}.6$.

I have fourteen observations of the star, which taken in connection with the above, seem to favor its variability. My observed magnitudes are as follows:

	M		M
1892 July 20,	8.2	1892 Aug. 29,	8.0
23,	7.8	Sept. 9,	8.5
30,	7.9	20,	8.5
Aug. 3,	7.9	27,	8.5
7,	7.9	Oct. 11,	8.5
13,	7.9	19,	8.8
21,	8.0		

Dorchester, 1892 *October* 20.

OBSERVATIONS OF THE OCCULTATIONS OF *MARS*, OF JULY 11 AND SEPTEMBER 3, 1892,

MADE AT THE OBSERVATORY OF THE STATE UNIVERSITY OF MISSOURI, AT COLUMBIA, MO.,

BY MILTON UPDEGRAFF.

These observations were made with the 7½-inch equatorial telescope of this Observatory, using a power of 150. The times were noted by eye and ear on sidereal chronometer, Bond, no. 383.

1892 *July* 11.

Contact	Obs'd Times	Remarks	Chron. ΔT	Obs'd sid. time of contact
	h m s		s	h m s
I	17 5 48	poor	+0.5	17 5 48.5
II	. . .	lost	+0.5	. . . . .
III	18 5 13	about 2^s late	+0.8	18 5 13.8
IV	18 6 13.5	good	+0.8	18 6 14.3

Observation of first contact made through a tree-top at low altitude. Seeing very poor.

Observation of second contact lost; the moon and planet being obscured by the leaves of the tree.

Seeing excellent at third and fourth contacts. Snow-cap on south pole of *Mars* very well defined.

1892 *September* 3.

Cont.	Obs'd Times	Remarks	Chron. ΔT	Obs'd sid. time of contact
	h m s		s	h m s
I	22 50 37	good; possibly 2^s late	+11.5	22 50 48.5
II	22 51 30.8	excellent	+11.5	22 51 42.3
III	23 59 25*		+11.8	23 59 36.8
IV	0 0 0	through clouds	+11.8	0 0 11.8

* Through clouds; probably 10^s late.

Seeing excellent at first and second contacts.

Observations of third and fourth contacts were made at a low altitude, through clouds, and with bad seeing.

PRELIMINARY NOTE ON TERRESTRIAL ATMOSPHERIC ABSORPTION OF THE PHOTOGRAPHIC RAYS OF LIGHT.

BY J. M. SCHAEBERLE.

As the tabular data given below may be of immediate use to some astronomers, I have thought it well to publish them at once. They are deduced from an extended investigation which I took up in 1889 at the suggestion of Professor HOLDEN. The observations (exposures), measures, and the method of reduction form the subject matter of a memoir now being published by the University of California.

The final results are based upon four different series of observations, as follows:

1st series. At Mt. Hamilton in September, 1889.
2d series. At Cayenne, S. A., in December, 1889.
3d series. At Mt. Hamilton, July and August, 1890.
4th series. At Mt. Hamilton, in November, 1891.

The exposures for the 3d series were kindly made for me by Prof. CAMPBELL, who, at the time, was spending his vacation at the Lick Observatory; the other three series of exposures were made by myself.

All the observations, with the exception of those belonging to the 4th series (which were made with our Crocker telescope), were made with a 6-inch equatorially mounted Dallmeyer lens belonging to the U. S. Naval Observatory, and loaned to the Lick Observatory primarily for the purpose of taking it to our eclipse station at Cayenne.

Before the reduction of the observations on atmospheric absorption of the photographic rays of light could be undertaken, it was evidently necessary to determine the relation which exists, for the given telescope, between the diameters of the stellar images for known exposure times, and the brightness of the corresponding stars. Some results of an investigation on this subject will be found in the Publications of the *Astronomical Society of the Pacific*, Vol. I, no. 1. See also *Astronomical Journal*, no. 269.

It is not necessary for me to make any extended remarks as to how the observations were made and reduced, as the memoir on this subject will soon be in the hands of astronomers.

The final empirical expression which represents the law of photographic absorption is one of a series of formulæ, of which nearly the whole mass of material was worked over by the method of least-squares) which best represents all the observations.

I found that

If B_z denotes the photographic brightness of a star in the zenith.

B_ζ denotes the photographic brightness of a star at a zenith distance ζ degrees.

and f, a constant for a given state of the atmosphere, then

$$B_\zeta = B_z(1 - f\cdot\tan\frac{\zeta}{2})$$

In this expression $\frac{\zeta}{2}$ is to be regarded as an abstract number whose square expresses the number of degrees of which the trigonometrical tangent is required. For

mal condition of the atmosphere, and for Sirian type stars the value of the factor *f* is 0.60.

The tables given below are computed for these conditions, using the same light-ratio for the photographic magnitudes that is employed in visual determinations.

The argument for entering the table is the observed zenith distance, the corresponding function is the amount of the (photographic) atmospheric absorption expressed in photographic *magnitudes*.

These values are to be added to the (unknown) absorption in the zenith to obtain the absolute absorptions.

In presenting the following results to astronomers for practical use, I feel quite confident that they will be found to be sufficiently accurate for all exposures made on SEED plates, sensitometer No. 26, which have been *fully* developed.

Mt. Hamilton, 1892 *October* 20.

TERRESTRIAL ATMOSPHERIC ABSORPTION OF THE PHOTOGRAPHIC RAYS.

Obs'd Z. D.	Absorption Photogr.	Obs'd Z. D.	Absorption Photogr.	Obs'd Z. D.	Absorption (Photogr.)
	M		M		M
0	0.00	55	0.56	80	1.9
5	0.00	60	0.71	81	2.1
10	0.01	65	0.89	82	2.2
15	0.04	70	1.12	83	2.3
20	0.07	75	1.45	84	2.5
25	0.11	80	1.94	85	2.7
30	0.16	85	2.68	86	2.9
35	0.21	90	5.00	87	3.3
40	0.28			88	3.7
45	0.35			89	4.2
50	0.44			90	5.0

OBSERVATIONS OF THE SOLAR ECLIPSE OF 1892 OCTOBER 20.

AT THE COLUMBIA COLLEGE OBSERVATORY, AT N.Y., WITH THE RUTHERFURD 13-INCH EQUATORIAL, BY MR HAROLD JACOBY.

At the request of Prof. J. K. REES, Director of the Observatory, I noted the times of first and last contact, as follows:

	Columbia College M.T.
	h m s
First contact,	0 40 2
Last contact,	3 10 59

The seeing was very good, and the observations satisfactory. They were made with a chronograph. The clock error was determined by chronographic comparisons with the time signals of the Western Union Telegraph Company. These latter depend upon the noon-signals from Washington. Through the courtesy of Prof. EASTMAN of the Naval Observatory, and Mr. HAMBLET of the telegraph company, I was able to assure myself of the accuracy of the signals on the 20th. They were further confirmed by transit-observations made on the 22d by Mr. MONELL, assistant in the observatory. In the reductions the longitude of Columbia College was taken to be 4h 55m 54s.9 west of Greenwich.

New York, 1892 *November* 1.

AT THE LEANDER McCORMICK OBSERVATORY, BY PROF. ORMOND STONE.

Beginning	23h 51m 31s.6	Local Mean Time
End	2 50 55 .6	" " "

The above observations were made with the 26-inch equatorial, reduced to an aperture of 6 inches. Magnifying power employed 275. Definition at the beginning, poor; at the end, good.

AT PRINCETON, N.J., BY PROF. C. A. YOUNG.

The eclipse was observed both at the Halsted Observatory, and at the Observatory of the School of Science, which is connected with my house.

At the former station the observations were made by my assistant, Mr. TAYLOR REED, aided by Mr. H. S. DAVIS. Mr. REED observed *spectroscopically*, by noting the disappearance and reappearance of the chromosphere as seen in the *C* line with an opened slit; he used the 23-inch equatorial, with grating spectroscope, and magnifying power of 350. Mr. DAVIS observed with the 5-inch finder, using an ordinary diagonal solar eyepiece and a power of about 120. The times were taken from a sidereal chronometer, which was carefully compared with the standard sidereal clock at the S.S. Observatory, both before and after the observations; at the first contact it was 1m 27s.7 fast of the standard, and at the last, 1m 28s.0. This indirect method of furnishing the time at the Halsted Observatory was made necessary in consequence of the interruption of our usual electrical connections by building operations on the campus.

At the S.S. Observatory, I observed, myself, with the 9½-inch telescope, using a polarizing helioscope, and power of 225; while my son, C. I. YOUNG, observed the first contact with the 3-inch finder, and a diagonal solar eye-piece, with power of about 60. We took the time directly from the face of a subsidiary clock which is electrically controlled by the standard clock, the beats of the sounder being those

of the standard itself. At the time of the eclipse the standard was slow 7.6 seconds, with a gaining rate of about 0ˢ.08 daily.

The times of first contact were as follows: —

Obs.	Chron. or Clock	Remarks	Corresp'g Gr. M.T.
	h m s s		h m s
T. R.	14 6 55.5 ± 0.7	not good	5 5 15.1
H. S. D.	14 6 53.0 ± 0.5	fair	5 5 12.6
C. A. Y.	14 5 17.0 ± 1	air unsteady	5 5 34.3
C. I. Y.	14 5 20.0	air unsteady	5 5 37.3

I am unable to explain the discrepancy between the observations at the two observatories; according to computation, the first contact at the Halsted Observatory should have been 2.6 seconds earlier than at the S.S., being 1ˢ.98 west, and 2″ south of it. The observers at both places are confident that there was no error of 10 seconds in reading off the face of the time-piece. There was, however, at the S. S. a sudden atmospheric tremor just at the time of contact, lasting from 5ᵐ 15ˢ to 5ᵐ 22ˢ; but at its close the definition, which before had been fine, became so again at once, and the moon's limb then seemed to me [illegible] sun.

The observations of last contact were as follows:

Obs.	Time-piece	Remarks	Corresp'g G. M. T.
	h m s		h m s
T. R.	17 8 29.5	fair	8 6 [illegible]
H. S. D.	17 8 28.5	good	8 6 48.[illegible]
C. A. Y.	17 7 1.5	satisfactory	8 [illegible] 59.1

During the eclipse fourteen photographs of the [illegible] of the moon's limb and the cusps were made; but none of them show the slightest traces of absorption by a lunar atmosphere.

For a time about the middle of the eclipse the definition was simply exquisite at the S.S. Observatory, and it was very interesting to watch with a power of 500 the granulations of the solar surface as the moon's limb moved over them. They passed out of sight behind the lunar mountains without the least haziness or distortion of outline. The limb of the moon could at no time be traced beyond that of the sun.

Princeton, N.J., 1892 *October* 28.

AT THE GEORGETOWN COLLEGE OBSERVATORY, BY J. G. HAGEN, S.J.

1. The eclipse was observed here with three *instruments*:

A 5-inch equatorial, power 98 for both contacts; observer, J. HAGEN.

A 3¼-inch equatorial, power 72 for I, and 50 for II, contact; observer, J. ALGUÉ.

A photographic camera, focus 8½-inch, diaphragm $\frac{1}{16}$-inch; observer, H. GOWER.

The first observer recorded the time by means of the chronograph, the second by a pocket-chronometer whose second-hand could be stopped at any moment, with a direct reading of fifths of seconds; the third observer, a student of the College, used a watch.

The standard clock had been compared with the clock of the U.S. Naval Observatory on the chronograph, five or six minutes before first contact. The error of the latter clock was —0ˢ.15, as subsequently communicated through the kindness of the Superintendent.

The rate of our own clock was 0ˢ.02 during the three hours of the eclipse.

2. The *times* of observed and computed *contacts* are as follows:

	5-inch equat'l	3¼-inch equat'l	Computed
	h m s	h m s	h m s
I Contact	5 5 31.7	5 5 36.5	5 5 20.3
II Contact	8 5 45.0	8 5 45.6	8 5 50.6
Duration	3 0 13.3	3 0 9.1	3 0 30.3

Greenwich Mean Time.

The observing sheets contain the following explanations:

HAGEN: I Contact recorded when I was sure of seeing the moon's limb; the first impression was received at least one second earlier.

II Contact recorded at the moment I was no longer sure of seeing the moon's limb.

ALGUÉ: I Contact recorded when I was quite sure of seeing the moon; the first impression was perhaps two seconds earlier.

3. The *magnitude* of the eclipse at this station was determined from two of the ten photographs that [illegible] taken.

Time	6 35 0	[illegible]
Diameter of sun	13.1688	13.1[illegible]
Segment of sun	5.648	5.[illegible]
Magnitude	0.5811	[illegible]

The numbers for diameter and segment are [illegible] revolutions of the micrometer-screw [illegible]. Each number is the mean of ten [illegible] errors have been applied.

All the computations [illegible] ALGUÉ, S.J.

ELLIPTIC ORBIT FOR COMET *e* 1892 *BARNARD*.*

Prof. KRUEGER writes that from observations of Oct. 16, 20 and 25, he has obtained elliptic elements, which were confirmed by a Vienna observation of Oct. 27. They give a period of 10.4 years.

Epoch = 1892 Oct. 20.5 Berlin M.T.

$$\begin{aligned} M &= 355\ 27.9 \\ \left.\begin{aligned} \omega &= 167\ 41.9 \\ \Omega &= 204\ 38.9 \\ i &= 32\ 41.9 \end{aligned}\right\} &\ \text{Eq. 1892.0} \\ \varphi &= 43\ 38.6 \\ \mu &= 341''.681 \end{aligned}$$

EPHEMERIS FOR BERLIN MIDNIGHT.

	h	m	s		'
Nov. 5	20	30	55	+4	23.1
9		42	28	3	6.9
13	20	51	21	1	54.5
17	21	6	39	+0	46.4
21		19	10	—0	16.9
25	21	34	56	—1	15.3

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MAGNITUDES OF *NOVA AURIGAE* CORRECTED FOR ATMOSPHERIC ABSORPTION,

BY J. M. SCHAEBERLE.

At the time of writing my paper on *Theoretical Magnitudes of Nova Aurigae*, I was engaged in revising my work on *Atmospheric Absorption of the Photographic Rays of Light*; so that I was still somewhat uncertain as to what the magnitude of the final corrections would be.

In all the provisional photographic results I have taken *Polaris* as a standard star of the magnitude 2.00 *at the mean zenith distance* 52° 40′ where the absorption of the photographic rays (according to my investigation now definitely finished) is $0^{\rm M}.50$. The photographic magnitude of *Polaris* in the zenith on this same scale is therefore $1^{\rm M}.50$.

In this paper I shall only consider the corrections to be applied to the magnitudes of *Nova Aurigae* as published in no. 269 of the *Astronomical Journal*.

All the observations, as stated in the paper referred to, are of a differential character. So that after having once determined the constant correction to the magnitudes of the comparison-stars, we have simply to apply this same correction to the magnitudes of the *Nova*.

While making the exposures on β *Tauri*, χ *Aurigae* and DM. 30°, nos. 898 and 963, for determining their photographic magnitudes, these stars were all less than 15° from the zenith, so that the effect of absorption is practically zero. At these same times the altitude of *Polaris* was roughly the same as the latitude of the place, so that the correction for absorption was $-0^{\rm M}.50$ for all exposures on *Polaris*.

Assuming now that *Polaris* has the magnitude 2.00 *in the zenith*, all the above mentioned comparison-stars will on this new scale be just half a magnitude fainter than the values given in *Astronomical Journal*, no. 269.

That is

$$\begin{aligned} \beta\ \textit{Tauri} &= 1^{\rm M}.58 \\ \chi\ \textit{Aurigae} &= 4.90 \\ \text{DM. } 30^\circ 898 &= 5.72 \\ \text{DM. } 30^\circ 963 &= 5.48 \end{aligned}$$

while *Polaris* at the observed zenith distance 52° 40′ has the observed (uncorrected) magnitude 2.50.

All my photographic magnitudes of *Nova* up to and including March 9, will require the same correction, viz: $+0^{\rm M}.50$.

In determining the corrections after March 9, we have only to deal with the "standard" positive plate. This plate was exposed $2^{\rm h}\ 30^{\rm m}$, beginning at the zenith distance 25°, and ending at the zenith distance 55°.

At 25° the absorption is $0^{\rm M}.11$, and at 55° its value is $0^{\rm M}.56$. It is rather uncertain just what value to use for the whole exposure. The mean of the two extremes is probably too great. A closer value is probably that which corresponds to the mean zenith distance. I have therefore taken $0^{\rm M}.30$ as the correction for absorption for the standard plate. The correction to be applied to all magnitudes found by means of the standard plate is therefore

$$\text{Corr.} = +0^{\rm M}.50 - 0^{\rm M}.30 = +0^{\rm M}.20$$

All the magnitudes after March 9 are therefore to be increased 0.20 magnitudes.

For greater convenience the final values are given below.

PHOTOGRAPHIC MAGNITUDES CORRECTED FOR ATMOSPHERIC ABSORPTION.

Date 1892	Photogr. Mag.	Date 1892	Photogr. Mag.	Date 1892	Photogr. Mag.
*Feb. 6	5.13	Feb. 21	5.34	Mar. 9	6.66
8	5.01	25	5.40	10	7.30
9	5.17	26	5.54	11	7.90
10	5.27	27	5.25	13	7.90
11	4.9	28	5.48	15	8.65
12	5.0	Mar. 2	5.70	16	8.80
13	4.8	3	5.59	20	9.45
14	4.53	4	6.13	21	9.60
15	5.72	6	5.90	22	9.75
21	5.46	7	6.40	24	10.00
22	5.62	8	6.59	25	10.20

* For the exact times of observations see *Astron. Jour.*, no. 269.

It will be noticed, by those who have given this star particular attention, that the visual and photographic magnitudes are now practically identical.

In my uncorrected results the sudden jump in magnitude between March 9 and March 10 is now shown to be due to atmospheric absorption. I did not fully realize the magnitude of the corrections from this source, otherwise I should not have delayed communicating my results to the Journal until the present time.

Mt. Hamilton, 1892 *October* 22.

ELEMENTS AND EPHEMERIS OF COMET *d* 1892 (*BROOKS Aug.* 28).*

BY GEORGE A. HILL.

Communicated by the Superintendent of the U. S. Naval Observatory.

From observations made on Aug. 31 at Kiel, on Sept. 18 at Göttingen, and on Oct. 7 at Hamburg, I have computed the following elements and an ephemeris of the above comet.

The places have been corrected for parallax and aberration, and the unit of brightness is that of date of discovery.

$$T = 1892 \text{ Dec. } 28.11941 \text{ Gr. M.T.}$$

$$\left.\begin{aligned} \Omega &= 264^\circ\ 32'\ 36''.2 \\ \omega &= 252\ 23\ 21.9 \\ i &= 24\ 45\ 10.8 \end{aligned}\right\} \text{Mean Eq. 1892.0}$$

$$\log q = 9.991529$$

Residuals.

$$\Delta\lambda \cos\beta \quad +11''.5$$
$$\Delta\beta \quad -3.1$$

Following are the values of the constants for the equator,

$$x = r\,[9.958561]\sin(v + 216^\circ\ 23'\ 4''.5)$$
$$y = r\,[9.975774]\sin(v + 147\ 19\ 15.7)$$
$$z = r\,[9.723032]\sin(v + 203\ 49\ 34.0)$$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1892.0	α	δ	log Δ	Br.
	h m s	° '		
Nov. 16	10 19 51.2	−1 30.6	9.9700	20.7
17	24 23.1	2 29.1		
18	28 57.2	3 28.2		
19	33 31.1	4 27.7		
20	38 11.0	5 27.9	9.9581	23.3
21	42 57.2	6 28.5		
22	47 43.4	7 29.5		
23	52 32.3	8 30.7		
24	10 57 23.6	−9 32.1	9.9494	25.7
25	11 2 16.9	−10 33.6		
26	7 12.5	11 35.1		
27	12 10.6	12 36.6		
28	17 11.3	13 37.9	9.9442	27
29	22 14.5	14 38.9		
30	27 20.2	15 39.6		
Dec. 1	32 28.2	16 39.9		
2	37 38.7	17 39.7	9.9427	[illegible]
3	42 51.5	18 38.8		
4	48 6.6	19 37.3		
5	53 23.8	20 34.9		
6	11 58 43.2	21 31.9	9.9447	[illegible]
7	12 4 4.7	22 27.8		
8	9 28.2	23 22.1		
9	14 53.1	24 16.6		
10	20 20.5	25 9.3	9.9498	[illegible]
11	25 49.1	26 1.1		
12	31 20.0	26 51.7		
13	36 51.5	27 40.8		
14	42 24.4	28 28.5	9.9575	[illegible]
15	47 58.3	29 14.8		
16	53 33.2	29 59.7		
17	12 59 8.7	30 43.2		
18	13 4 45.5	31 25.3	9.9676	[illegible]
19	10 23.0	32 6.0		
20	16 1.0	32 45.3		
21	21 39.2	33 23.1		
22	27 17.7	33 59.4	9.9792	[illegible]
23	32 56.3	34 34.3		
24	38 32.8	35 7.7		
25	44 10.7	35 39.7		
26	13 49 47.4	36 10.2	9.9920	[illegible]

Naval Observatory, Washington, D.C.

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OBSERVATIONS OF COMET *f* 1892 (*HOLMES*),

MADE AT THE HARVARD COLLEGE OBSERVATORY,

BY O. C. WENDELL, ASSISTANT.

Communicated by Prof. E. C. PICKERING, Director.

1892 Cambridge M.T.	⁎	No. Comp.	Comet − ⁎ Δα	Comet − ⁎ Δδ	Comet's apparent α	Comet's apparent δ	log pΔ α	log pΔ δ
Nov. 8 9 20 6	1	4	−2 3.21	−5 56.0	0 46 18.78	+38 23 22.6	[illegible]	[illegible]
13 58 39	1	5	−2 10.26	−6 41.2	0 46 11.73	+38 22 37.4	[illegible]	[illegible]
10 13 15 32	2	5	−1 46.87	+12 56.8	0 45 12.37	+38 11 13.6	[illegible]	[illegible]
11 9 7 33	2	5	−2 11.11	+8 4.2	0 44 38.12	+38 6 21.1	[illegible]	[illegible]

Mean Places for 1892.0 of Comparison-Stars.

⁎	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ' "	"	
1	0 48 18.96	+3.03	+38 28 52.9	+25.7	W_1 Bessel 0, 1193
2	0 46 56.23	+3.01	+37 57 50.8	+26.0	Lalande 1443

FILAR-MICROMETER OBSERVATION OF COMET *e* 1892 (*BARNARD, Oct. 12*),

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY.

BY E. E. BARNARD.

1892 Mt Hamilton M.T	*	No. Comp.	☌ — * $\Delta\alpha$	☌ — * $\Delta\delta$	☌'s apparent α	☌'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
Nov. 7 6h 37m 4.8s	9	12 , 4	—1m 11.98s	+1′ 44.1″	20h 37m 7.32s	+3° 42′ 42.9″	9.170	0.688

Mean Place for 1892.0 of Comparison-Star.

*	α	Red. to app. place	δ	Red. to app. place	Authority
9	20h 38m 17.61s	+1.66s	+3° 41′ 22.7″	+9.1″	Grant 5219

Comet excessively faint and difficult, but observation good. It has faded very much since the last observations. It is scarcely probable this object can be followed very much longer.

Mt. Hamilton, 1892 *Nov.* 8.

ELEMENTS AND EPHEMERIS OF COMET *e* 1892 (*BARNARD, Oct. 12*).*

BY GEORGE E. WHITAKER.

These parabolic elements were computed from the observations of BARNARD at the Lick Observatory, Oct. 15, 18 and 25, the observations of the 13th and 19th having been omitted from apprehension of some error in transmission.

ELEMENTS.

$$T = 1892\ \text{Nov. } 25.8458\ \text{Greenw. M.T.}$$

$$\left.\begin{aligned}\omega &= 159^\circ\ 23'\ 14''\\ \Omega &= 197\ \ 39\ \ \ 1\\ i &= \ 35\ \ 40\ \ 32\end{aligned}\right\}\ \text{M. Eq. } 1892.0$$

$$\log q = 0.22353$$

The discordance of the middle place is

$$(O-C)\cos\beta\cdot\Delta\lambda = +1'\ 34''.2 \qquad \Delta\beta = -10''.0$$

The resultant heliocentric coordinates for the equation are:

$$\begin{aligned}x &= [9.99310]\,r\,\sin(v+\ \ 83^\circ\ 52'\ 47'')\\ y &= [9.99231]\,r\,\sin(v+355\ \ 50\ \ \ 3)\\ z &= [9.40996]\,r\,\sin(v+131\ \ 23\ \ \ 2)\end{aligned}$$

A comparison of the resultant ephemeris with the observations given on p. 102 indicates that the declination there given for Oct. 19 is 1′ too large; and thus explains the discordance of the various systems of elements obtained by employment of this observation.

1892 *November* 12.

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1892	App. α	App. δ	log r	log Δ	Br.
Oct. 11.5	19h 29m 19s	+13° 18′.0	0.2498	0.1357	1.00
13.5	33 32	+12 33.0			
15.5	37 52	+11 48.1	0.2456	0.1367	1.01
17.5	42 20	+11 3.4			
19.5	46 55	+10 19.0	0.2417	0.1383	1.02
21.5	51 38	+ 9 35.0			
23.5	19 56 27	+ 8 51.4	0.2382	0.1406	1.03
25.5	20 1 23	+ 8 8.4			
27.5	6 26	+ 7 25.9	0.2350	0.1436	1.03
29.5	11 35	+ 6 44.1			
31.5	16 49	+ 6 3.0	0.2321	0.1472	1.02
Nov. 2.5	22 9	+ 5 22.7			
4.5	27 34	+ 4 43.2	0.2297	0.1516	1.01
6.5	33 1	+ 4 4.7			
8.5	38 39	+ 3 27.2	0.2276	0.1568	1.00
10.5	44 18	+ 2 50.6			
12.5	50 1	+ 2 15.0	0.2260	0.1623	0.98
14.5	20 55 47	+ 1 40.6			
16.5	21 1 36	+ 1 7.3	0.2247	0.1686	0.96
18.5	7 28	+ 0 35.2			
20.5	13 23	+ 0 4.4	0.2239	0.1756	0.93
22.5	19 20	— 0 25.1			
24.5	25 20	— 0 53.4	0.2236	0.1831	0.90
26.5	31 21	— 1 20.4			
28.5	37 24	— 1 46.0	0.2236	0.1912	0.87
30.5	43 28	— 2 10.3			
Dec. 2.5	21 49 31	— 2 33.3	0.2241	0.2000	0.83

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CONTENTS.

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THE

ASTRONOMICAL JOURNAL.

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SUPPLEMENT TO RECENT CONTRIBUTIONS TO CHRONOLOGY AND ECLIPSES.

BY JOHN N. STOCKWELL.

1. In number 251 of this Journal Mr. Lynn has given some further criticisms of my investigations concerning the chronology of certain ancient events; and strange to tell, he claims that my investigations lead to conclusions directly opposite to those which I have stated. I shall therefore endeavor to show that Mr. Lynn's inferences are altogether erroneous; and that the conclusions at which I have arrived, are not only legitimate and correct, but are also fully confirmed by the discussion of other and independent data.

2. Mr. Lynn's inference that I reject the statement of Suetonius in regard to age of Augustus at the time of his death, simply because it is opposed to my views, is certainly not correct. I accept the testimony of Josephus in regard to his age, because it harmonizes various historical and astronomical events; whereas, the testimony of Suetonius is at variance with that of Josephus, and does not accord well with astronomical phenomena. And, as I have already remarked in a former paper, the credibility of a historian is measured by the fidelity with which his statements correspond with facts which can be independently determined; it follows that in the present instance, the greater merit should be accorded to Josephus.

3. Mr. Lynn also maintains that the light of the "waning moon, five days before conjunction," would be sufficient to disturb the slumbers of Calpurnia in the manner described by Plutarch. Now, I am willing to admit in a general way, that the moon, five days before or after conjunction, would in some cases be quite conspicuous in the heavens during nearly one-half of the night; but in order to show that such was the case on the morning of the fifteenth of March in the year B.C. 44, it is necessary to show that the moon was then so situated in the heavens as to fulfil that condition. Now, I find that at the time of moonrise at that date, the moon had an apparent declination at Rome of 27° south; and that it rose at 4^h 20^m in the morning; whereas twilight commenced at 4^h 35^m, or only one-quarter of an hour later; and the sun itself rose at 6^h 12^m. Therefore, the moon rose only 1^h 52^m before the sun, on that occasion. Besides, only about *three-tenths* of the moon's disk was then illuminated; and the feebleness of its light, taken in connection with the shortness of the time before the incipient twilight of the morning, renders it very improbable that any disturbance would arise from its presence above the horizon. But if the assassination of Caesar took place in B.C. 45, the amount and condition of the moonlight was very different. For the moon was then almost exactly at the full; and it was high in the heavens during nearly the whole night; and the effect ascribed to its presence, would legitimately follow.

The assumption that the slumbers of the sleeping Calpurnia were disturbed by the moonlight of a practically moonless night, certainly lacks the element of plausibility; while his interpretation of the narrative concerning the time of moonrise on the fifth of March, during the Spanish War, not only differs from that of other classical scholars, but also seems destitute of a plausible reason on the part of the historian for any allusion whatever to the moon, in that connection; and I fancy that Mr. Lynn would hardly have advanced them as arguments, except in support of an otherwise untenable hypothesis.

4. In regard to the date of the death of Darius, I can only say that my conclusions stated in a former paper, were based on the assumption that his death occurred in the same Olympic year as the battle of Arbela. I find, however, that according to Arrian, the death of Darius occurred during the first month of the following Olympic year. But I also find that neither Arrian nor Plutarch makes any reference to the Olympiads in connection with the battle of Arbela, or with the death of Darius; so that Rollin does not state an *historical fact* in regard to the date of the death of Darius, but merely gives the computed Olympic year of his death, based on the assumption that the first Olympiad was celebrated in the year B.C. 776.

Having thus disposed of Mr. Lynn's animadversions, I shall now proceed to give some additional evidence from eclipses in support of the conclusions already arrived at.

5. A very important eclipse of the sun is that recorded by Phlegon, an inhabitant of Tralles, a city of Lydia, in Asia Minor, who lived in the second century of our era. He wrote a work on the Olympiads, in sixteen books, but this

work is unfortunately lost; and we are indebted to other writers of antiquity for the preservation of a few fragments from his important work. The date of the eclipse is referred to the Olympic era by Phlegon; but unfortunately his commentators differ so much among themselves that nothing can be determined from them as to its date, without resorting to astronomical calculation. Rev. Samuel Farmar Jarvis devotes a whole chapter of his *Chronological History of the Church* to Phlegon and his eclipse; and professes to give all that is known on the subject. I am indebted to his work for the materials here given. There is a substantial agreement among the half-dozen authorities given by Jarvis, in so far as they are descriptive of the eclipse itself; but the dates to which it is referred embrace a period of six years.

The earliest date given, is by John Philoponus, a grammarian of Alexandria, who lived early in the seventh century. His account is as follows: "He [Phlegon] says that in the second year of the 202d Olympiad, there happened an eclipse of the sun greater than all which had been known before: and night took place at the sixth hour of the day, so that stars appeared in the heavens."

If the first Olympiad was celebrated in the year B.C. 776, the *second* year of the 202d Olympiad would be A.D. 30. Now, the only eclipse of the sun at all answering to the above description about that period of time occurred A.D. 29, Nov. 24; when the sun was central and totally eclipsed at noon about two degrees to the westward of Tralles, and a little to the southward of that place. There can therefore be no doubt as to the year in which the eclipse actually took place. Now, it is a curious fact, that if the first Olympiad occurred in B.C. 776, *all* the commentators, and Phlegon himself, who had made a special study of the Olympiads, were wrong; but if the first Olympiad occurred in the year B.C. 777, it follows that the statement of Philoponus and Phlegon were both correct. This is a perfectly satisfactory and triumphant confirmation of the conclusions previously arrived at from the discussion of other eclipses, and from historical considerations.

6. A second important eclipse occurred a short time after the commencement of the reign of the Emperor Vespasian, and serves to determine the first year of his reign. The beginning of the reign of Vespasian is variously given by historians; the dates ranging from A.D. 68 to A.D. 70. According to Dion Cassius, the reign of Vespasian commenced on the first day of July, which preceded the decisive battle of Cremona. On this point, Jarvis, in his *Chronological History of the Church*, page 317, remarks: "The decisive battle of Cremona must have been fought on the 29th of October. It began about nine o'clock in the evening, and continued the whole night, 'various, doubtful, atrocious.' The sun rose upon them as they were fighting. Dion Cassius, who has given a most eloquent description of this battle, mentions a circumstance omitted by Tacitus, which enables us to fix its date. 'While this commotion existed in the army of Vitellius, it was greatly increased by an eclipse of the moon, which to their terrified minds seemed not only overshadowed, but to be black and bloody, and to emit other fearful colors. The soldiers, however, did not on this account desist from their purpose, but when Primus [the general of Vespasian's army] sent messengers, they sent others exhorting them to submit to Vitellius. This brought on a severe battle, though the soldiers of Vitellius were without a general: for Alienus [Cassina] was in chains in Cremona.'

"At sunrise a panic seized the soldiers of Vitellius, and they fled to Cremona. The moon was then in the western horizon, and the approaching light of the sun in the east, and the exhalations in the west, produced the variety of colors by which the soldiers were terrified."

Dion Cassius further relates that certain presages of misfortune happened to Vitellius. "A comet was seen, and the moon was twice eclipsed, contrary to the usual course, to wit, once on the fourth day, and another time the seventh. Two suns were also seen at the same time, one in the east which was clear and dazzling, and one in the west which was pale and obscure."

If Dion means to say that the eclipses occurred on the fourth and seventh days of the week, the last eclipse mentioned must have happened on Oct. 29, A.D. 68, which was a Saturday; as neither of the large partial eclipses of the moon which took place in A.D. 69, occurred on a Saturday. Besides, the two suns mentioned as being visible at the same time must have been the real sun, bright and dazzling in the east, and the totally eclipsed moon on the western horizon, which would have appeared pale and obscure. The nearly total eclipse of the moon which took place A.D. 69, Oct. 18, occurred before midnight, and the darkness thus produced would have seriously interfered with the fighting in the night-battle; a circumstance not mentioned by the historian.

There can therefore no longer be any doubt that Vespasian's reign commenced July 1, A.D. 68; and this agrees with the statement of Pliny that the two eclipses occurred within fifteen days of each other during the *third* year of his reign, which ended June 30, A.D. 71; for we have already shown that those two eclipses happened in March of that year.

7. We shall now briefly recapitulate the astronomical evidence which we have been able to collect; and we shall easily perceive that it is entirely harmonious and conclusive in its character.

First. The date of Caesar's assassination is shown by two astronomical phenomena to have been March 15, B.C. 45, instead of B.C. 44. These phenomena were, the *time* of moonrise on March 5, during Caesar's Spanish War; and the *moonlight* on the night preceding the day of his death; which we have seen could not possibly have existed in B.C. 44.

Second. The death of AUGUSTUS is proved by the eclipse of the moon on Oct. 7, A.D. 13, to have taken place on the nineteenth of the preceding August; or one year earlier than usually given by chronologists.

Third. The reign of VESPASIAN commenced on July 1, A.D. 68. This is proved by the eclipse of the moon at the time of the battle of Cremona, Oct. 29, A.D. 68; and also by the two eclipses mentioned by PLINY, which occurred within fifteen days of each other: that of the moon happened on March 4, and that of the sun on March 20, of the year A.D. 71; which was the third year of his reign.

8. We thus have six astronomical phenomena showing that the chronology of the early Roman emperors should be antedated by one year. Moreover, the year when CENSORINUS wrote his work, *De Die Natali*, is determined by the succession of the Roman consuls; and as we have already shown that the first emperors should be antedated by one year, it follows that the date of CENSORINUS should be earlier by one year. CENSORINUS therefore wrote his book, *De Die Natali*, in A.D. 237, instead of A.D. 238.

Now, CENSORINUS gives us the connecting link between *Grecian* and *Roman* history, when he tells us that the year in which he wrote was the 1014th from the first Olympiad, and the 991st from the founding of Rome. Therefore $237 - 1013 = -776 =$ B.C. 777 = date of first Olympiad; and $237 - 990 = -753 =$ B.C. 754 = date of the founding of Rome. Moreover, according to VARRO, Rome was founded in the third year of the sixth Olympiad; therefore it was founded in the year $-781 + 27 = -754 =$ B.C. 755. But since it was founded during the last half of the Olympic year, its true date would be B.C. 754; the same as deduced from CENSORINUS.

Fourth. We have seen that the eclipse of ENNIUS took place in the year B.C. 404; and since this eclipse occurred 350 years after the founding of Rome, we have B.C. $(404 + 350) =$ B.C. 754 = year in which Rome was founded.

Fifth. We have seen that the Persian invasion of Greece by XERXES took place in the year B.C. 481; and as the Olympic games were celebrated that year, it is evident that it was the first year of the seventy-fifth Olympiad. Therefore seventy-four Olympiads, or 296 years had passed since the first Olympiad was celebrated; and consequently the first Olympiad occurred B.C. $(481 + 296) =$ B.C. 777. This is also confirmed by the statement of THUCYDIDES, who tells us that the Persian War under XERXES preceded the Peloponnesian War by fifty years; and as we have found that the Peloponnesian War commenced in B.C. 431, it is evident that the first Olympiad occurred in the year B.C. 777.

Sixth. But the most direct and decisive evidence that the first Olympiad was celebrated in the year B.C. 777, is afforded by the eclipse of PHLEGON. For there can be no possible doubt that it took place in the year A.D. 29, Nov. 24; because there were no other eclipses visible in that part of the world, between the years A.D. 17 Feb. 15, and A.D. 49 May 20, that would at all correspond with the description given by PHLEGON. We thus have no less than *ten* distinct astronomical phenomena bearing either directly or indirectly upon the date of the first Olympiad; and they all unite in fixing that date in the year B.C. 777.

9. We may therefore summarize a few of the more important dates of history which we have been able to determine astronomically, as follows:

First. PLUTARCH'S eclipse happened A.D. 113 June 7.

Second. Jerusalem was destroyed by TITUS in A.D. 69, instead of A.D. 70.

Third. VESPASIAN became emperor July 1, A.D. 68, instead of A.D. 69.

Fourth. The eclipse of PHLEGON occurred A.D. 29, November 24.

Fifth. AUGUSTUS died in August A.D. 13, instead of A.D. 14.

Sixth. The last year of confusion in the Roman calendar was B.C. 47, instead of B.C. 46.

Seventh. The first year of the Julian calendar was B.C. 46.

Eighth. CAESAR'S Spanish War was in the years 47 and 46 B.C.

Ninth. CAESAR was assassinated on March 15, B.C. 45, instead of B.C. 44.

Tenth. HEROD'S eclipse occurred either Sept. 15, B.C. 5, or March 13, B.C. 4; and HEROD died early in the year B.C. 4.

Eleventh. *Jerusalem* was taken by POMPEY in B.C. 65; and by HEROD in B.C. 38.

Twelfth. The battle of *Pydna* took place B.C. 172 September 3, as recorded by LIVY.

Thirteenth. The eclipse of PELOPIDAS occurred B.C. 364 July 13.

Fourteenth. The eclipse of ENNIUS occurred B.C. 404 September 3.

Fifteenth. ALEXANDER the Great was born B.C. 357.

Sixteenth. The Persian invasion of Greece by XERXES occurred in the year B.C. 481, instead of B.C. 480.

Seventeenth. The eclipse of LARISSA occurred B.C. 547 Oct. 23, instead of B.C. 557 May 19, as determined by AIRY.

Eighteenth. The eclipse of THALES occurred B.C. 603 May 18.

Nineteenth. *Rome* was founded B.C. 754 April 22

Twentieth. The era of the *Olympiads* commenced in July, B.C. 777, instead of B.C. 776.

10. Since the year A.D. 29 was the second year of the 202d Olympiad, as determined by the eclipse of PHLEGON, it follows that the 202d Olympiad was celebrated in the year A.D. 28, which was a bissextile year; and hence the Olympiads were celebrated in the bissextile years of the Julian calendar. This is what CENSORINUS affirms in his work, *De Die Natali*, chap. 18; as stated by SEYFFARTH in his *Chronologie*, &c.; and the same thing is affirmed by SEXTUS JULIUS AFRICANUS, as quoted by GRESWELL in his *Harmony of the Gospels*, Vol. I, page 273, note. SEYFFARTH also states that the Olympic games were celebrated three months after

the assassination of Julius Caesar, which of course would be a bissextile year if it took place in B.C. 45; but a common year if it took place in B.C. 44. Moreover, Censorinus states that the year in which he wrote his book, *De Die Natali*, was the *second year of the two hundred and fifty-fourth Olympiad*. The first year of the two hundred and fifty-fourth Olympiad was therefore A.D. 236, which was a leap year; and this is an additional confirmation of the fact established by the eclipse of Phlegon.

Having thus discussed all the eclipses which a very limited examination of classical literature has brought to my notice, I shall now proceed to the discussion of a subject which is somewhat closely allied to eclipses as a means of fixing the dates of historical events; and that is, the conjunctions of the planets.

11. Although the heliocentric conjunctions of the planets occur with a considerable degree of regularity, and are also very easily calculated; the geocentric conjunctions are subject to many inequalities in the periods of their successive occurrences; so that it requires somewhat elaborate computations to determine accurately the character of any geocentric conjunction of two planets which occurred in ancient times. On account of the frequency of planetary conjunctions, and the indefinite manner in which they are usually described, it becomes a matter of very great difficulty to identify any particular conjunction unless it is associated with some other event whose date can be independently determined. A remarkable case of this character is given in the Bible; for Matthew informs us that in the days of Herod the king, "there came wise men from the east to Jerusalem, saying 'where is he that is born King of the Jews? for we have seen his star in the east, and are come to worship him.'" From the subsequent inquiries and mandates of Herod the king, concerning the *time* when the star appeared, we are led to infer that its appearance took place within two years preceding the death of Herod; and it has been sought to explain the appearance of the star by means of a conjunction of the planets, — the Creator employing celestial phenomena to proclaim "the good tidings of great joy, which shall be to all people."

The illustrious Kepler was the first to suggest that the star of the wise men might be explained by means of a conjunction of the planets *Jupiter* and *Saturn*; and he even undertook to calculate the times when such conjunctions took place. Much has been said and written on the subject of the "star of the wise men" during the past few years; but no important contribution to the *natural history* of the star has been made since the days of Kepler, nearly three hundred years ago. But the *supernatural history* and functions of such a star have been discussed in a very able and interesting manner by many writers in theological, literary, and semi-scientific periodicals during the past twenty years; and perhaps nothing of interest and importance can now be added to what has already been published on that subject. I find, however, that Kepler overlooked one important element of the problem, in his calculations; and consequently left the natural history of the problem in an incomplete and unsatisfactory condition. I shall therefore here attempt to complete more fully what Kepler began; and show that the Biblical narrative concerning the "star in the east," is better satisfied by a conjunction of *Venus* and *Jupiter*, than by any of the conjunctions computed by Kepler.

12. We have already seen that the death of Herod took place early in the year B.C. 4; and if we can now show that there was a very conspicuous conjunction of two bright planets, visible only in the east, within two years preceding that date, the hypothesis that such conjunction was the event referred to in the Biblical narrative will at least be rendered plausible, if not entirely legitimate; and for this purpose I have here undertaken the calculation of all the conjunctions of the planets which took place near that epoch.

I shall first inquire whether there was a conjunction of the planets *Jupiter* and *Saturn* about that period of time which would satisfy the required conditions. The mean interval between two heliocentric conjunctions of *Jupiter* and *Saturn* is 7253.4638 days; and they were in mean conjunction B.C. 6 Jan. 30. Now the time of *true* heliocentric conjunction may differ from the time of *mean* heliocentric conjunction by 241 days, on account of the inequalities in their elliptic motions; and by 23 days more by reason of the great inequalities of long period in their mean motions. But the time of geocentric conjunction of *Jupiter* and *Saturn* may differ from the time of heliocentric conjunction by 102 days; so that a geocentric conjunction *may* occur one whole year before or after the time of mean heliocentric conjunction. In the present instance I find that the true heliocentric conjunction took place B.C. 7 Sept. 23, which is 129 days before the mean heliocentric conjunction; and that there were three geocentric conjunctions during the year B.C. 7, which took place as follows:

The first conjunction took place June 7, in which *Saturn* passed 1° 1′ to the south of *Jupiter*; the second conjunction took place Sept. 18, in which *Saturn* passed 1° 2′ to the south of *Jupiter*; and the third conjunction occurred on Dec. 15, in which *Saturn* passed 1° 8′ to the south of *Jupiter*.

In the first conjunction the planets would have an elongation of about 73° to the westward of the sun, and would be seen during four or five hours in the east, in the morning. The second conjunction took place near the time of opposition with the sun, and would be visible during the whole night, so that it could not properly be designated as a *star in the east* any more than a *star in the west*. In the third conjunction the planets would have an elongation of about 84° to the eastward of the sun, and could therefore appear only as evening stars in the west. Moreover, *Saturn* is not an especially bright planet, and consequently no one of these three conjunctions could have been very conspicuous

in the heavens. The first conjunction was the only one which was visible in the east; but since it occurred nearly *three years* before the death of Herod, it could hardly be said to satisfy the conditions required by the narrative. No other conjunctions of *Jupiter* and *Saturn* could possibly occur until about twenty years later, so that we may conclude with a high degree of probability that the phenomenon alluded to in the Bible was not occasioned by a conjunction of *Jupiter* and *Saturn*.

13. Since the planet *Mars* is a conspicuous object when near its opposition with the sun, it may be well to inquire whether a conjunction of *Mars* and *Jupiter* might not occasion the phenomenon referred to. But since *Mars* is conspicuous only when near its opposition with the sun, it is evident that any conjunction when in that position would appear as a star in the *west* as much as in the *east*, and consequently would not fulfill the required conditions. There was, however, a conjunction of *Mars* and *Jupiter* on March 5, B.C. 6; but at that time the planet's elongation was only 18° to the eastward of the sun, and consequently could have been visible only in the west. But *Mars* was then so far from the earth, and so nearly in conjunction with the sun, that the conjunction would be wholly invisible. At the same time *Saturn* was not very far from *Jupiter*; and hence it was said that there was a triple conjunction of the planets *Mars*, *Jupiter* and *Saturn* in the spring of B.C. 6.

14. It is evident without calculation that there could be no conspicuous conjunction of *Venus* and *Mars* at any time; because *Mars* is not a conspicuous planet unless its elongation from the sun be greater than the greatest elongation ever attained by *Venus*, so that it would be a waste of time and labor to enter into the computation of any such conjunctions.

15. It now remains to inquire whether the two brightest planets of the solar system, *Venus* and *Jupiter*, might not have been in conjunction within a short time before the death of Herod, and constitute the phenomenon alluded to in the Biblical narrative; for it was the beautiful phenomenon presented by these two planets when in conjunction last February, that suggested this investigation.

Now the conjunctions of *Venus* with the sun occur with great regularity at intervals of about 584 days, while those of *Jupiter* occur at intervals of 399 days. Moreover, it may easily be shown that all geocentric conjunctions of *Venus* and *Jupiter* must take place within about 60 days before or after *Jupiter's* conjunction with the sun. Therefore by tabulating the times of *Jupiter's* conjunctions with the sun, we have only to investigate the longitude of *Venus* for a period of sixty days before or after that event in order to determine whether a conjunction of those planets will then take place.

Now I find that *Jupiter* was in mean conjunction with the sun B.C. 6, March 29, while *Venus* was in conjunction on the preceding fifth of November, or 144 days earlier than *Jupiter*. *Venus* had therefore passed her [illegible] elongation and was moving toward [illegible] tion, and she would overtake *Jupiter* [illegible] M[illegible] mutual elongations from the sun were [illegible] 27° [illegible] west. At that time the heliocentric latitudes of *V*[illegible] and *Jupiter* were 3° 21′ and 1° 20′ south; wh[illegible] latitudes were 1° 10′ and 1° 8′ south, respectively. [illegible] fore follows that at the time of their geocentric [illegible] *Jupiter* was only 32′, or about the [illegible] moon to the northward of *Venus*. And as [illegible] to the westward of the sun, they would [illegible] as a star in the east a couple of hours before sunrise. These two brightest planets in the sky would [illegible] the time of conjunction, B.C. 6 May 8, be [illegible] close together, and produce a striking and [illegible] pearance. The date also at which it took place, [illegible] about fifty days less than two years before [illegible] Herod, harmonizes well with the spirit and [illegible] tions of the narrative. For it is probable that [illegible] for the slaughter of the children of two years old [illegible] was issued some months before his decease; [illegible] of *two years* would leave an ample margin for [illegible] tainty as to the time of the appearance of the star, as [illegible] by the Magi.

There were no other conjunctions of *Venus* and *Ju*[illegible] until the year B.C. 2, or nearly two years after the de[illegible] Herod, when there were two conjunctions, one of w[illegible] occurred on August 31, and the other on October [illegible]. The first of these was invisible on account of being too near the sun; but the second took place when *Venus* was [illegible] her greatest elongation to the westward of the sun.

16. If the preceding calculations, and the [illegible] based on them, are correct, it follows that Christ was [illegible] as early as May in the year B.C. 6; and if he was [illegible] at the time of a paschal full moon, which occurred on Friday, it must have taken place on April 3, [illegible] A.D. 33. And since any given phase of the moon [illegible] peated on the same day of the week, and also w[illegible] two days of the same time of the year, at intervals of [illegible] tions, or 27 years, it follows that there w[illegible] pas[illegible] full moons on a Friday between the years A.D. 6 and A.D. [illegible], except the one on April 3, A.D. 33. W[illegible] to follow that Christ was thirty-eight years [illegible] of his crucifixion and death; and the [illegible] sagacity of the Jewish Doctors, wh[illegible] that he (Christ) was not then fifty [illegible]

This close conjunction of *Venus* [illegible] combination — the symbols of love [illegible] with dignity and power — was a fit[illegible] birth of a Prince who was to bring [illegible] will towards men; and is, perhaps, [illegible] tion of the truth of the Biblical [illegible] origin of the Christian dispensation [illegible] having a purely scientific basis.

Cleveland, Ohio, 1892 *Oct.* 10.

EPHEMERIS OF COMET *a* 1892 (*SWIFT*).*

By F. GERTRUDE WENTWORTH.

(Continued from p. 96.)

G.M.T.	App. α	App. δ	log Δ	Br.	G.M.T.	App. α	App. δ	log Δ	Br.
1892	h m s	° ′			1892	h m s	° ′		
Nov. 15.5	23 44 11.4	+34 36.2			Dec. 9.5	23 53 55.3	+29 41.9		
17.5	45 3.6	34 6.9	0.4231	0.021	11.5	55 1.9	29 23.0	0.5005	0.013
19.5	45 51.4	33 38.5			13.5	56 16.9	29 5.0		
21.5	46 3.2	33 10.9	.4359	.019	15.5	57 34.8	28 47.8	.5132	.012
23.5	46 40.2	32 44.1			17.5	23 58 49.7	28 31.5		
25.5	47 21.3	32 18.2	.4488	.018	19.5	0 0 10.4	28 16.0	.5258	.011
27.5	48 6.5	31 53.0			21.5	1 33.1	28 1.3		
29.5	48 55.5	31 29.1	.4618	.016	23.5	2 58.2	27 47.1	.5384	.010
Dec. 1.5	49 48.0	31 5.9			25.5	4 25.4	27 34.2		
3.5	50 45.0	30 43.5	.4748	.015	27.5	5 54.7	27 21.8	.5503	.009
5.7	51 45.0	30 22.1			29.5	7 26.1	27 10.2		
7.5	23 52 48.3	+30 1.5	0.4876	0.014	31.5	0 8 59.4	+26 59.4	0.5622	0.009

* Printed in a Supplement issued with no. 279.

OBSERVATIONS OF COMET *f* 1892 (*HOLMES*).

The following observations of this comet have been received, and the first three were printed and distributed in the Supplement to no. 279.

FROM PROF. BOSS AT THE DUDLEY OBSERVATORY.

1892 Albany M.T.	✱	No. Comp.	☄ — ✱ Δα	☄ — ✱ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
Nov. 13 7h 19m 47s	Ll.1143	27 . 9	−2m 58s.78	−3′ 38″.0	0h 44m 0s.80	+37° 54′ 34″.9	. .	. .

Mean Place for 1892.0 of Comparison-Star.

α	Red. to app. place	δ	Red. to app. place	Authority
0h 46m 56s.60	+2s.98	+37° 57′ 13″.5	+26″.4	Lund, Astr.Gesellsch.(2 obs.), Paris(1 obs.)

The comet appears like a very large, bright, round nebula, about 9′ in diameter, slightly defective on the s. foll. edge, with a well-marked central condensation. Its faint nucleus is elongated in $p = 110$°, approximately. Computations convince me that this is Biela's comet, that it will reach perihelion about Dec. 27, and come very close to the earth about Nov. 27.7 Greenw. M.T.

FROM PROF. J. B. COIT AT BOSTON UNIVERSITY.

1892 Washington M.T.	✱	No. Comp.	☄ — ✱ Δα	☄ — ✱ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
Nov. 11 8h 6m 59s.8	W.B.1083	17 . 7	+42s.54	−2′ 44″.4	0h 44m 51s.76	+38° 6′ 41″.9	n9.050	9.850

Mean Place for 1892.0 of Comparison-Star.

α	Red. to app. place	δ	Red. to app. place	Authority
0h 44m 6s.24	+2s.98	+38° 9′ 0″.1	+26″.2	Weisse's Bessel 1083

Prof. Coit writes that on the evening of Nov. 13 he saw the comet distinctly with the naked eye. It seemed about 1½ magnitudes fainter than α *Andromedae*.

FROM PROF. BARNARD AT THE LICK OBSERVATORY.

1892 Mt. Hamilton M.T.	✱	No. Comp.	☄ — ✱ Δα	☄ — ✱ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
Nov. 8 8h 23m 41s	Paris 1105	12 , 4	−0m 48s.52	−4′ 26″.2	0h 46m 16s.26	+38° 23′ 4″.5	n9.228	8.700
12 47 19	Paris 1105	2 , 1	−0 55.35	−5 30.8	0 46 9.43	+38 21 59.4	9.655	0.133

Mean Place for 1892.0 of Comparison-Star.

α	Red. to app. place	δ	Red. to app. place	Authority
$0^h\ 17^m\ 1.76^s$	$+3.02^s$	$+38°\ 27'\ 5.0''$	$+25.7''$	Paris 1105

The second position was simply observed to get amount of motion, and is not perhaps very accurate.

The comet was easily visible to the naked eye, as a small hazy star, and almost exactly as bright as the brightest part of the great nebula in *Andromeda*. With the 12-inch telescope it was perfectly circular and singularly well defined. Two measures at midnight gave the diameter as 4′ 35″.

FROM PROF. YOUNG, AT PRINCETON (OBSERVATIONS BY MR. T. REED).

1892 Greenwich M.T.	*	No. Comp.	☄ – * Δα	☄ – * Δδ	☄'s apparent α	☄'s apparent δ	log p Δ	
Nov. 21 $15^h\ 37^m\ 6^s$	1	18	$+16.49^s$	. .	$0\ 12\ 5.54$	. . . .	9.158	. .
$16\ \ 7\ \ 2$	1	10	. . . .	+10.0	. . . .	$+37\ 3\ 7.1$	. .	0.763

Mean Place for 1892.0 of Comparison-Star.

α	Red. to app. place	δ	Red. to app. place	Authority
$0^h\ 41^m\ 46.56^s$	$+2.488^s$	$+37\ 2\ 28.5$	$+28.80$	W.B. O. 1029

PHOTOGRAPHIC AND VISUAL OBSERVATIONS OF COMET *f* 1892 (*HOLMES*).

By E. E. BARNARD.

The first night that I observed this comet (Nov. 8) I did not examine it with a low power until after moonrise — the micrometer with a high power being used to measure the position before moonrise.

The following night, Nov. 9, however, showed besides a short, faint, hazy tail, a faint nebulous atmosphere about 12′ in diameter, symmetrically surrounding the well-defined disc of the comet. This hazy atmosphere was also seen with the 4-inch comet seeker.

On the 10th I made a photograph of this object with three hours exposure ($6^h\ 15^m$ to $9^h\ 15^m$ Standard Pacific Time) using the 6-in. Willard lens and a Cramer "Lightning" plate, the comet being followed. This long exposure, of course, would totally burn out any of the brighter detail, and was given with the hopes of finding out something about the comet's surrounding.

This plate showed the bright, circular disc as a dense, sharply-defined, round spot, very slightly diffused, south following. Symmetrically surrounding this was the circular, nebulous atmosphere, strongly marked and fairly well defined, and 12′ in diameter. A rather narrow and faint tail, over half a degree long, was also shown pointing to the southeast. At the extremity of the tail, nearly a degree from the comet, was a faint and very vague looking nebulosity, perhaps half a degree in diameter.

This I am certain belongs to the comet, and may be a diffused nebulous attendant. In a night or two, when the moon will permit a longer exposure in the morning sky, I will try it again with four or five hours exposure, to verify the connection of this diffused nebulous attendant with the comet.

Visually with the 12-inch, the n.p. edge of the comet proper is singularly well defined, while the s.f. edge is somewhat less definite. Take it altogether, however, there is no diffusion of the well-defined disc into the hazy atmosphere that surrounds the comet.

With a low power the object looks like a planet with faintly surrounding atmosphere.

The nucleus is eccentrically placed, being on the preceding side of the middle of the disc, while near the centre of the comet is a second brightening, and from this an elongated condensation extends south following. The general appearance of the comet is that of the vertical [illegible] of a cone — gradually brightening towards the apex. The nucleus is small and ill-defined.

With the naked eye on Nov. 9, the comet seemed to be brighter and more stellar than on the preceding night. On the 10th it may possibly have been a little brighter yet. It was a little less bright than ν *Andromedae*.

Mt. Hamilton, 1892 *Nov.* 11.

ELLIPTIC ELEMENTS OF COMET 1892 *f* (*HOLMES*).

By REV. GEORGE M. SEARLE.

I attempted to compute an orbit for this comet from the earlier observations, and obtained one bearing some resemblance to that of BIELA; but the middle place could not be represented satisfactorily except by an exaggerated hyperbola. On plotting the observations with [illegible], however, it became evident that the rough discovery observation was altogether too inaccurate to be of service in such delicate work. The problem was therefore taken up anew

from the observations by Wendell on Nov. 8 and 11, with two of mine on Nov. 11 and 13,—the former being combined into one place with that made by Wendell at nearly the same time.

It soon became evident that, with the ratio of the distances resulting from the observations, indicating that the comet was slowly receding, no parabolic chord could be put in at any place between the lines of observation. An observation having been obtained here on Nov. 16, the unrestricted computation was therefore undertaken from Nov. 8, 11, and 16. The following result has been obtained:

$$T = \text{Oct. } 11.9802 \text{ Gr.M.T.}$$

$$\left.\begin{aligned} \omega &= 62^\circ\ 19'\ 2'' \\ \Omega &= 325\ \ 11\ \ 16 \\ i &= 19\ \ 16\ \ 13 \end{aligned}\right\}\ 1892.0$$

$$\log a = 0.525258$$

$$\log e = 9.504648$$

Period 2241 days.

This orbit represents the observations thus far, reduced to latitude and longitude, as follows (O—C):

1892	$\Delta\lambda$ ″	$\Delta\beta$
Nov. 8	0	0
11	— 2	— 7
13	+ 1	—21
16	0	0
18	+12	— 9

The orbit is certainly an extraordinary one in its small eccentricity, being more like that of an asteroid than of a comet; it is noticeable, however, that the aphelion is not very far from the orbit of *Jupiter*. The principal arguments against its being approximately the true one, would be probably the enormous size which the comet must have, to subtend such an angle at the distance indicated (about 1.5), and the certain, if not great, increase in its size since discovery; but it has certainly steadily become fainter.

There is another positive root to the solution equation for distance, but the distance given by it is so great that it seems comparatively unlikely. The accordance of the five observations with the present orbit is favorable to it, but perhaps not conclusive.

According to this orbit the nearly stationary appearance of the comet is simply due to its being in that position, with regard to opposition, in which such would naturally be the case.

The comet appears to-night (Nov. 20) still fainter, about 15′ in diameter, slight central tail on the following side.

Ephemeris for Greenwich Midnight.

1892	α h m s	δ ° ′ ″	log Δ	Br.
Nov. 23.5	0 42 1	+36 50.1	0.1751	0.87
27.5	42 23	36 24.0	.1839	0.83
Dec. 1.5	43 18	35 58.6	.1929	0.80
5.5	0 44 17	+35 34.4	0.2025	0.76

The position at the time of discovery is, according to this orbit, $\alpha = 0^h\ 47^m\ 29^s\ (= 11^\circ\ 52'.2)$, $\delta = +38^\circ\ 34'.2$: it would appear then that a mistake of 10′ was made in the discovery-observation as it has been given, probably occurring in the reduction from time to arc. This error gave the comet an apparently accelerated motion, and indicated an approach to the earth.

Washington, D.C., 1892 *Nov.* 21.

METEORIC SHOWER.

A notable display of meteors attracted the attention of many observers on the evening of November 23. Prof. Rees telegraphs from New York City that he counted more than two hundred in forty minutes; their radiant being about 10° northeast of Comet *f*. The Editor of this Journal estimated those casually seen by himself as equally numerous.

COMET *g* 1892.

A rather bright nebulous object, suspected to be a comet, was found, Nov. 19, by Mr. Brooks, at Geneva, N.Y., in the approximate position.

$$\alpha = 12^h\ 56^m, \quad \delta = +12^\circ\ 59'$$

A position obtained by Mr. Wendell, at the Cambridge Observatory, gives

Cambr. M.T.	α	δ
Nov. 21 16ʰ 44ᵐ 38ˢ	12ʰ 59ᵐ 15ˢ.62	+13° 50′ 27″.3

Daily motion, $+1^m.6$ in α, and 25′ northward.

It is described as 1′.5 in diameter; circular, with a tolerably well-defined nucleus, and about 10ᴹ.5.

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ON THE DIVISION-ERRORS OF THE GRADUATED SCALE USED IN THE RUTHERFURD PHOTOGRAPHIC MEASURES OF THE PLEIADES.

By WM. A. ROGERS.

In the admirable Memoir of Mr. JACOBY, the author states on page 242 of the *Contributions from the Observatory of Columbia College*, that "The method employed (in investigating the division-errors of the Rutherfurd scale) was not such as would free the results from cumulative error, but it is highly probable that a sufficient degree of accuracy for the present purpose has been attained."

Inasmuch as the writer endeavored in this investigation to take strict account of the cumulative errors of the scale, it is, perhaps, desirable that a brief account should be given of the method employed. In view of the prominence which will be given to photographic measurements in the near future, this discussion may serve a useful purpose. Moreover, the results obtained by Mr. JACOBY will have additional value if it can be shown that the division-errors employed in the reductions introduce no sensible errors.*

It will be seen from an examination of the table given on page 270, that the value of an average scale-division is 28″.01. It will also be seen from an examination of the table on page 250 that the maximum cumulative error of the scale is near line 217, where its value is 0.0297. The maximum error of the scale is, therefore,

$$28''.01 \times 0.0297 = 0''.83$$

The number of divisions of the micrometer corresponding to this value will be seen from an examination of the second table on page 243, to be about 76. The actual value for this particular space, as it appears in my manuscript, is 78.6 divisions. The value of one division will therefore be

$$\frac{0''.83}{78.6} = 0''.0106$$

If, therefore, we admit the existence of an error at any point as great as ten divisions of the micrometer, the resulting measures of the stellar positions will only be affected with an error of 0″.1. Since the probable error of a measurement of a single space is only four-tenths of a division, and for any value of the cumulative error in a summed series, does not much exceed three divisions, it will be seen that the results given in Mr. JACOBY's memoir are practically free from the effect of division-errors of the scale.

The method employed in measuring the relative errors of sub-divisions of the scale may be described as the "stop method." The microscope is attached to a plate which is carried over the ways of the comparator by means of a rack and pinion movement. At each end of the plate is inserted a hardened steel plug, having a rounded end. Two movable sliding plates are placed upon the ways on opposite sides of the microscope-carriage. These plates are firmly clamped to the bed of the comparator, at a distance apart such that the carriage, in passing from contact with one stop to contact with the other stop, moves over a space approximately equal to one of the spaces to be compared. The microscope carriage having been brought into contact with the left stop, the micrometer line of the microscope is brought into coincidence with the initial line of the space taken as the unit of measurement. The carriage is then moved till contact is made with the right stop, and a reading of the microscope is taken for coincidence with the terminal line of the space. If the stops are set exactly equal to the space measured, the micrometer has no work to do. In practice however, it is found advantageous to make the distance between the stops a little greater than the average scale-distance. The scale is then moved along upon the bed of the comparator parallel to itself, till a near coincidence with the first line of the second space is obtained, when the operation of measurement is repeated. In this way each successive space is compared with the constant distance between the stops. The method of procedure will appear from the following example:

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* Since this paper was prepared, the writer has learned through correspondence with Mr. JACOBY, that he uses the expression "cumulative errors" in a different sense from that in which it is used in the following discussion. He limits the expression to the case in which the results given, have different weights, such as would be likely to occur in any summed series.

	Spaces	Left Stop Div. of Mic.	Right Stop Div. of Mic.	(R−L)	Relative Corrections	Summed Series
				d	d	d
	1	4.4	8.8	+4.4	−0.4	−0.4
(1)	2	6.0	9.9	+3.9	−0.9	−1.3
	3	3.4	8.6	+5.2	+0.4	−0.9
	4	4.1	9.8	+5.7	+0.9	0.0
	5	2.6	7.4	+4.8	0.0	0.0
			Mean	+4.8		

Here, +4.8 div. represents the excess of the distance between the stops over the average distance between the lines of the graduated bar. Subtracting this mean from each value of (R—L) we have the series of relative corrections required to reduce each line to the position which it would occupy if all the spaces were equal; but each space has a new line of reference.

In the last column, the values in the preceding column are all referred to the initial line of the scale. The summed series, therefore, indicated by the usual symbol Σ, represents the cumulative errors of the entire system of subdivisions compared. According to the conventional nomenclature adopted, a negative sign indicates that the measured space is too long.

Instead of the "stop method" one may employ with equal advantage, the "two-microscope method," when the spaces compared do not fall much below 6 or 8 centimeters. The "stop method" has, however, the advantage of allowing comparisons between spaces having any value whatever. With regard to the precision of which the method is capable, it may be said that the probable error of a single contact between the stops is decisively less than the probable error of a single measured coincidence with the filar micrometer.

The use of a screw in the measurement of cumulative errors requires that the periodic errors of the screw shall be definitely determined. Since errors of this class vary, not only with the load carried by the screw, but also with temperature, and with the degree and kind of lubrication, this method is liable to lead to erroneous results, unless the greatest care is taken to secure the partial elimination of errors which it is possible to obtain in a limited degree by the method of comparison employed.

Judging by my own experience, the method is likely to give an appearance of precision which does not really exist.

In the application of the method here indicated, we are confronted with two sources of error, which baffle every effort at determination with perfect exactitude. They are the following:

(1) The values in the column of relative corrections, as shown in the example given, have the same weight, but the values in the summed series have different weights.

(2) The effect of an accidental error of observation at any point in the series of comparisons, will be to give a wrong value to the mean, and this error will appear in the summed series in the form of a periodic error. Let us suppose that in the following fictitious example, an accidental error x is introduced in the measurement of the fourth space. We shall then have:

Spaces	(R−L) div.	Relative Corrections	Summed Series
		div.	div.
1	+4	$0 - \frac{x}{10}$	$0 - \frac{x}{10}$
2	+6	$+2 - \frac{x}{10}$	$+2 - \frac{2x}{10}$
3	+3	$-1 - \frac{x}{10}$	$+1 - \frac{3x}{10}$
4	$+4 + x$	$+0 + \frac{9x}{10}$	$+1 + \frac{6x}{10}$
5	+2	$-2 - \frac{x}{10}$	$-1 + \frac{5x}{10}$
6	+1	$-3 - \frac{x}{10}$	$-4 + \frac{4x}{10}$
7	+3	$-1 - \frac{x}{10}$	$-5 + \frac{3x}{10}$
8	+7	$+3 - \frac{x}{10}$	$-2 + \frac{2x}{10}$
9	+2	$-2 - \frac{x}{10}$	$-4 + \frac{x}{10}$
10	+8	$+4 - \frac{x}{10}$	$0 + 0$
Mean =	$+4 + \frac{x}{10}$		

It will be seen from this table that the form of the periodic error introduced in the summed series depends on the point at which the accidental error is introduced.

There is apparently another source of error, which has given the writer much trouble, and which does not seem to admit of an easy explanation.

If the principal divisions are still further subdivided, the corrections derived for these subdivisions must be introduced into the principal summed series in such a manner that each correction shall be referred to the initial line.

If we assume that the corrections to the principal subdivisions have been correctly determined, the effect of these errors upon the secondary subdivisions will be found by distributing the errors proportionately over the spaces covered. The corrections for each line of the subsidiary series will then be found by adding the corresponding values in the two series.

The error to which attention is called, appears in the transfer of graduations from one bar to another, when one applies, in the process of ruling, the corrections to the graduations of the primary bar, determined in the manner indicated above. For example, in the construction of a standard meter subdivided into 1000 equal parts, it is always found that when the corrections to the primary sub-divisions are large in value, and irregular in sign, they appear in the transferred graduations in the form of errors of a periodic character reduced in magnitude. A similar result was found in the original division of a large index-wheel into 1000 equal parts. In both cases a third trial resulted in sets of graduations nearly free from errors of serious magnitude. In the case of the meter, a fourth trial gave the following results for the summed series.

CORRECTIONS.

	No. cases between 0.0*u* & 1.0*u*	No. cases between 1.0*u* & 2.0*u*	No. cases between 2.0*u* & 3.0*u*	No. cases between 3.0*u* & 4.0*u*
Decimeters,	5	2	2	0
Centimeters,	58	27	5	0
Millimeters,	652	205	37	6

A count of the number of relative errors in each group from which the summed series was derived, gave 856 cases in which the corrections fell between 0.0μ and 1.0μ.

It may be of interest to state that the time required for a complete investigation of the meter was about 80 hours.

It may be said that the existence of periodic errors, as shown in the transfer of graduations from one bar to another, may have been due to large accidental errors in the comparisons in the particular cases described, but the writer has obtained this result in a very large number of cases. In fact, no exception to this statement has so far been noted.

It may be mentioned in this connection, that the principal difficulty in making an exact reproduction of a standard scale, lies in the unequal depth of the cut of the ruling diamond at relatively hard and soft places in the metal. The writer has yet to find a metal whose difference of density at different points could not be detected in this way.

Admitting, then, the existence of at least two of the three classes of errors described, it is evident that their magnitude must be determined before an estimate can be made of the real precision of the comparisons.

Two methods were pursued in making this investigation.

I. The results obtained by the summation of the relative errors of successive aliquot parts of the scale were compared with those obtained for the same scale, following the method of observation and reduction given by Dr. BROCH in Volume V of the *Memoirs of the International Bureau of Weights and Measures*. The standard selected for comparison is a decimeter upon speculum metal, which is made the basis of all transfers by the writer to other bars of the same metal.

Comparisons were made between the following subdivisions:

1 − 2
1 − 3
1 − 4
1 − 5
1 − 6
1 − 7
1 − 8
1 − 9
1 −10

2 − 3
2 − 4
2 − 5
2 − 6
2 − 7
2 − 8
2 − 9
2 −10
2 −11

10 − 11
9 − 11
8 − 11
7 − 11
6 − 11
5 − 11
4 − 11
3 − 11

The absolute corrections of the millimeter subdivisions referred to the initial line, were then computed by the elegant method given on pages 1 − 21 of the *Memoirs*.

The results obtained in this way, together with those obtained by the summation of the relative errors derived from the comparisons, 1 − 2 2 − 3 . . . . 10 − 11, are placed side by side in the following table. The first column of numerical results contains the deviations from an assumed unit of comparison. The second column contains the relative corrections derived by subtracting the mean value of the corrections from each individual value. The third column contains the summed series obtained from the second column. The fourth column contains the computed results obtained from the discussion in which the method of BROCH was employed.

Line	R − L	Relative Corrections	Σ	From the Discussion	
	″	″	″	″	
2	−0.5	−0.4	−0.40	−0.49	+0.09
3	+0.0	+0.1	−0.30	−0.41	+0.11
4	+0.0	+0.1	−0.20	−0.38	+0.18
5	+0.2	+0.3	+0.10	−0.04	+0.14
6	+1.5	+1.6	+1.70	+1.76	−0.06
7	−1.5	−1.4	+0.30	+0.23	+0.07
8	+0.2	+0.3	+0.60	+0.72	−0.12
9	−1.1	−1.0	−0.40	−0.34	−0.06
10	−0.2	−0.1	−0.50	−0.48	−0.02
11	+0.1	+0.5	0.00	0.00	0.00
Mean	−0.1				

It appears from this discussion that the shorter method gives results which are practically identical with those obtained from the more elaborate investigation, the average difference being only 0.09μ. It will be seen, however, that the residual differences have a periodic form; a result which may always be expected in any summed series.

II. If a decimeter scale is subdivided into 10 equal parts, the summed series of corrections to the centimeter subdivisions may be obtained in two ways, viz:

(*a*) By 10 summations of the relative corrections to the subdividing lines.

(*b*) By a comparison of the two halves of the scale, and by a subsequent comparison of the centimeter subdivisions of each half, combined in separate series.

It is the practice of the writer to continue the comparison of the centimeter spaces until a substantial agreement between the summed series at the middle point and the result of the direct comparison between the two halves has been obtained. Usually, from two to three comparisons are found to be sufficient. If English units of length are employed, several combinations may be made.

This method of comparison and of reduction has been applied in determining the corrections of a combined decimeter scale subdivided to millimeters, and a 4-inch scale subdivided to tenths of inches. The particular scale investigated was made for Dr. THALEN of Upsala. It will be sufficient to give here the final corrections to the 41 lines of the English scale, and the mean deviations of these values from each of the five combinations which were formed. These combinations were as follows:

(*a*) Subdivision into 40 equal parts.

(*b*) Subdivision into 2 equal parts, and the subsequent subdivision of each of the 2 parts into 20 equal parts.

(*c*) Subdivision into 4 equal parts, and the subsequent subdivision of each of the 4 parts into 10 equal parts.

(*d*) Subdivision into 5 equal parts, and the subsequent subdivision of each of the 5 parts into 8 equal parts.

(*e*) Subdivision into 8 equal parts, and the subsequent subdivision of each of the 8 parts into 5 equal parts.

The average deviation of the results derived from different combinations from those derived from the mean of all the combinations is represented by the symbol Δ.

Spaces	Final Comb.	Δ	Spaces	Final Comb.	Δ	Spaces	Final Comb.	Δ	Spaces	Final Comb.	Δ	Spaces	Final Comb.	Δ
1	—0.30μ	0.01μ	9	+0.16μ	0.05μ	17	+1.02μ	0.08μ	25	+0.18μ	0.08μ	33	—0.20μ	0.06μ
2	—0.16	0.03	10	+0.12	0.05	18	+0.50	0.07	26	+0.06	0.06	34	—0.38	0.05
3	+0.08	0.03	11	+0.26	0.04	19	+1.24	0.08	27	+0.76	0.06	35	—0.53	0.02
4	+0.24	0.04	12	+0.74	0.12	20	+1.56	0.07	28	+1.10	0.05	36	—0.24	0.05
5	+0.68	0.03	13	+0.72	0.06	21	+1.38	0.08	29	+0.56	0.03	37	+0.18	0.02
6	+0.74	0.04	14	+0.32	0.09	22	+1.02	0.06	30	+0.06	0.03	38	—0.34	0.01
7	+0.92	0.06	15	+0.58	0.08	23	+1.38	0.06	31	+0.12	0.03	39	—0.08	0.01
8	+0.50	0.07	16	+0.90	0.07	24	+1.08	0.07	32	+0.04	0.03	40	0.00	0.00

It appears from this discussion, that the average deviation of the corrections for a single space, from the mean of the results derived from the different combinations, is 0.1μ, a result nearly identical with that found from the first discussion. It seems safe to conclude, therefore, that in the summation of ten values of (R—L) no error greater than 0.4μ is likely to occur, when the comparisons are made with care.

It is to be noted that the close agreement of the results in the direct summation of the millimeter corrections with the mean values must be considered as accidental, since ordinarily it would be impossible to make 40 summations without introducing systematic deviations of considerable magnitude. It is doubtful if anything is gained by making the summations exceed ten.

We are now prepared to apply the method of reduction indicated in this paper to the values of (R—L) given on page 243 of the memoir by Mr. Jacoby. It is to be understood that the designation "error of spaces" represents corrections to the graduations, and that the term "total error" means the correction of the position of each graduation referred to the initial line.

It is obvious that the values given in Tables 1 and 2, on page 243, represent exactly the cumulative errors for the particular points selected, provided no errors of observation exist, and that the alternate values for the 25-spaces, should agree with the corresponding values for the 50-spaces under the same condition. The extent of the agreement will be seen from the following table. One division of the micrometer = $\frac{1}{5}\mu$.

Spaces	Summed Series 25 Spaces	Summed Series 50-Spaces	Diff.
0 — 25	+ 8.4 div.	–	–
25 — 50	+ 4.1	+ 5.5 div.	+1.4 div.
50 — 75	+11.7	–	–
75 — 100	+ 4.3	+ 4.8	+0.5
100 — 125	+30.0	–	–
125 — 150	+61.2	+59.6	—1.6
150 — 175	+67.8	–	–
175 — 200	+72.1	+69.2	—2.9
200 — 225	+75.8	–	–
225 — 250	+43.7	+45.8	+2.1
250 — 275	+43.9	–	–
275 — 300	— 5.9	+ 0.0	+5.9
300 — 325	0.0	–	–

Omitting the extrapolated value, +5.9, it will be seen that the differences at all points fall well within the accidental errors of observation; introducing into the photographic measures no error exceeding 0″.03.

For these particular points, therefore, no one will contend that the cumulative errors are not fully taken into account. The only doubt remaining relates to the introduction of the corrections of the 5-spaces given on page 244, and the subsequent introduction of the corrections for the single spaces. In order to remove all doubt in regard to the 5-spaces, the comparisons were repeated a sufficient number of times to secure an approximate agreement of every fifth number of the 65 summations with the values in the corresponding 25-spaces. In order to economize space in printing, only the mean results are given on page 244. This agreement was found to be fairly good, but not sufficiently good to allow the use of this series as definitive results. Greater freedom from error was secured by connecting the results for the 5-spaces with those of the 25-spaces, as shown in the following table. The values for the principal points are enclosed in brackets.

Spaces	25-Spaces div	5-Spaces div.	Sum div.
0	0.0	0.0	0.0
5	+1.7	—2.6	— 0.9
10	+3.4	—1.2	+ 2.2
15	+5.1	—5.2	— 0.1
20	+6.8	+9.0	+15.8
25	[+8.4]	0.0	+ 8.4
30	+7.6	—4.2	+ 3.4
35	+6.7	—2.9	+ 3.8
40	+5.9	—6.8	+ 0.9
45	+5.0	—4.5	+ 0.5
50	[+4.1]	0.0	+ 4.1

In a similar manner the corrections for the single space were combined with those for the 5-spaces. Thus, from page 245 we have:

Spaces	5-Spaces div	Single Spaces div	Sum div
0	0.0		
1	—0.2	—5.6	—5.8
2	—0.4	—2.9	—3.3
3	—0.6	—3.5	—4.1
4	—0.8	+2.0	+1.2

Spaces	5-Spaces div	Single Spaces div	Sum div
5	[—0.9]	0.0	—0.9
6	—0.3	—2.2	—2.5
7	+0.3	+1.4	+1.7
8	+0.9	+1.0	+1.9
9	+1.5	—3.2	—1.7
10	[+2.2]	0.0	+2.2

In conclusion, it may be of interest to call attention to the fact that the Rutherfurd scale was ruled with the same screw which produced the magnificent gratings made by Mr. **CHAPMAN**. It will not escape notice that perfect definition in a grating is not incompatible with linear errors of considerable magnitude in the ruling screw, even when they have a well defined periodic character. This conclusion was reached and published by the writer several years ago, but it found little credence at that time. The same conclusion was afterwards reached from an investigation of the errors of long period in a series of five gratings sent to the writer by Professor ROWLAND. The evidence seems to be decisive that the perfection of a grating depends upon freedom from periodic errors introduced by single revolutions of the ruling screw, rather than upon errors introduced through a change of pitch in different revolutions.

Colby University, Waterville, Maine, 1892 *Oct.* 30.

OBSERVATIONS OF COMET *f* 1892,

MADE AT VASSAR COLLEGE OBSERVATORY.

BY MARY W. WHITNEY.

1892 Poughkeepsie M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ [illegible]	log $p\Delta$ [illegible]
	h m s		m s	′ ″	h m s	° ′ ″		
Nov. 11 11 12 26	1	4	+0 56.80	—3 54.3	0 44 46.01	+38 5 32.0	9.430	0.612
16 11 4 41	2	10	—0 41.92	—2 32.8	0 42 58.56	+37 31 52.8	9.473	0.693
18 10 59 59	3	5	—2 45.70	—5 37.4	0 42 33.60	+37 22 9.6	9.481	0.[illegible]7
19 7 33 21	4	6	—0 8.78	—6 54.1	0 42 23.41	+37 16 53.3	n9.223	9.9[illegible]7
20 7 0 41	5	4	+0 24.70	+7 29.0	0 42 15.19	+37 10 24.2	n9.[illegible]	0.645

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 44 6.23	+2.98	+38 9 0.1	+26.2	W.B., O 1083
2	0 43 37.57	+2.91	+37 36 58.9	+26.7	Lalande 1323
3	0 45 16.39	+2.94	+37 27 20.2	+26.8	W.B., O 1116
4	0 42 29.29	+2.90	+37 23 20.5	+26.9	Compared with W.B., O 1116
5	0 41 47.62	+2.87	+37 2 28.2	+27.0	W.B., O 1029

On Nov. 19 a star of about 10ᴹ was observed within the densest part of the comet.

SWEEPING EPHEMERIS FOR BODIES MOVING IN THE BIELA-ORBIT.

BY S. C. CHANDLER

In view of the possibility that there may be several cometary bodies moving in the orbit of BIELA's comet, and the importance of their discovery, I have calculated the accompanying geocentric ephemeris of the trajectory for five dates in December, eight days apart. From these, if desired, that for any intervening date may be interpolated with sufficient precision for sweeping purposes. For convenience I have given, in the left-hand column, the dates of perihelion passage for a body which may happen to be found in the positions on the same horizontal line. The column "Br." gives the relative brightness, on the usual hypothesis, expressed in units of that for an object at the distance unity from the sun and the earth. A horizontal line is drawn in the table at about the point where BIELA's comet may itself be supposed to be, by a rude guess.

The basis of the ephemeris is the or[illegible] of M[illegible] w[illegible] calculated the principal perturbations to 186[illegible]. I [illegible] deemed it legitimate to assume that since [illegible] been no considerable disturbance by J[illegible] earth in any of its approaches, [illegible] sensibly [illegible] the plane or the eccentricity, or moved the axis [illegible] amount which will seriously affect the values of the [illegible] for the rough purpose in view.

At the point where the paths of the earth [illegible] ry orbit are close to each other, indicated by [illegible] values of the brightness, the ephemeris is necessarily discontinuous, since a body so situated would [illegible] pass into the opposite quarter of the sky. Although, [illegible] the uncertainty of the elements, the real trajectory is very doubtful in such case, I give, for the convenience of any

one who may desire to lay down on the chart those portions of the track, the following values of the

Heliocentric Equatorial Coordinates.

	Before Perihelion Passage			After Perihelion Passage		
	x	y	z	x	y	z
d						
64	+1.0659	+0.6158	+0.4290	−1.2727	−0.0397	−0.2810
56	0.9241	.6828	.4215	1.2003	+0.0873	.2236
48	.7730	.7426	.4096	1.1156	.2134	.1640
40	.6120	.7931	.3925	1.0175	.3365	.1023
36	.5280	.8143	.3818	0.9618	.3965	.0707
32	.4420	.8316	.3695	.9030	.4546	.0390
28	.3537	.8454	.3551	.8396	.5107	— .0070
24	.2637	.8550	.3397	.7723	.5644	+ .0250
20	.1724	.8598	.3220	.7011	.6149	.0569
16	+ .0800	.8598	.3026	.6254	.6619	.0884
12	— .0128	.8541	.2812	.5460	.7048	.1194
8	.1056	.8433	.2581	.4630	.7431	.1495
4	.1977	.8265	.2332	.3770	.7763	.1787
0	−0.2882	+0.8041	+0.2066	−0.2882	+0.8041	+0.2066

the interpolation of which, with the corresponding rectangular co-ordinates of the sun, will furnish the desired places very readily.

Bringing Michez's elements up to 1893.0, we have,

$$\omega = 223^\circ\,51'.4 \qquad \log a = 0.55915$$
$$\Omega = 216\;\;8.0 \qquad \log e = 9.87650$$
$$i = 12\;\;22.0 \qquad \mu = 530''.06$$

which give the equatorial coordinates,

$$x = [9.99151]\,r\sin(199^\circ\,32'.3 + v)$$
$$y = [9.97816]\,r\sin(105\;\;18.8 + v)$$
$$z = [9.56360]\,r\sin(140\;\;\;2.9 + v)$$

The true anomaly may be computed with needful accuracy by two terms of the series,

$$v = V + [1.15]A + [2.30]B$$

A and B being taken from Watson's Table IX, with the argument $v = V$ and V being found from Table VI with the argument $M = [0.01537]\,(t - T)$. All the above coefficients are logarithmic.

Geocentric Trajectory of Bodies Moving in the Biela-Orbit, in December, 1892.

Per. Pass.	Dates of Observation														
	1892 Dec. 2.5			Dec. 10.5			Dec. 18.5			Dec. 26.5			1893 Jan. 3.5		
	α	δ	Br.	α	δ	Br.	α	δ	Br.	α	δ	Br.	α	δ	Br.
1892	h m	° '		h m	° '		h m	° '		h m	° '		h m	° '	
Sep 29.5	13 57.7	−19 41	0.2												
Oct 7.5	13 47.6	19 18	0.2	14 10.2	−21 8	0.2									
15.5	13 36.9	19 13	0.3	14 0.5	20 53	0.2	14 22.5	−22 34	0.2						
23.5	13 25.4	18 19	0.4	13 50.1	20 36	0.3	14 13.1	22 30	0.3	14 34.4	−24 3	0.2			
31.5	13 13.0	17 45	0.5	13 39.6	20 25	0.4	14 3.1	22 25	0.4	14 25.3	24 8	0.3	14 45.9	−25 31	0.2
Nov 8.5	13 0.4	17 7	0.8	13 27.2	19 59	0.6	13 52.4	22 21	0.5	14 15.8	24 18	0.4	14 37.1	25 50	0.4
16.5	12 46.7	16 25	1.2	13 15.7	19 42	1.0	13 41.4	22 23	0.8	14 5.7	24 33	0.6	14 28.0	26 16	0.5
24.5	12 33.1	15 46	1.9	13 2.7	19 32	1.5	13 30.1	22 35	1.2	13 55.3	25 1	1.0	14 18.5	26 54	0.8
Dec 2.5	12 19.8	15 14	3.3	12 50.7	19 41	2.6	13 19.2	23 9	2.0	13 45.3	25 53	1.6	14 9.1	27 56	1.2
10.5	12 7.1	15 5	6.6	12 40.5	20 35	5.0	13 9.9	24 35	3.8	13 36.4	27 33	2.8	14 0.5	29 45	2.2
18.5	11 56.7	16 21	454.1	12 35.5	23 45	12.7	13 6.1	28 16	8.5	13 31.9	31 14	5.9	13 55.1	33 14	4.2
26.5	12 6.3	31 46	297.4	13 2.6	38 32	67.9	13 26.9	40 10	29.7	13 45.0	40 53	16.6	12 13.4	45 21	12.2
1893 Jan 3.5	23 15.7	− 0 56	58.4	22 34.5	26 49	107.3	20 52.0	57 5	107.2	17 31.4	67 25	62.6	15 36.6	62 56	34.2
11.5	23 11.9	+ 3 56	9.3	23 11.6	− 3 21	13.6	23 12.7	12 45	20.0	23 12.4	25 23	29.1	23 44.7	43 32	41.1
19.5	23 4.2	4 36	3.4	23 10.5	+ 0 57	4.4	23 20.3	− 3 3	5.9	23 33.3	7 45	6.4	23 48.7	13 35	11.3
27.5	22 56.3	4 30	1.7	23 5.0	2 17	2.0	23 16.9	+ 0 8	2.6	23 32.2	− 2 6	3.3	23 50.6	4 30	4.3
Feb 4.5	22 48.9	+ 1 10	0.9	22 58.4	2 42	1.1	23 50.9	1 24	1.3	23 26.5	+ 0 15	1.7	23 45.2	− 0 48	2.2
12.5				22 51.7	+ 2 42	0.7	23 44.3	1 54	0.8	23 19.7	1 18	1.0	23 37.8	+ 0 54	1.2
20.5							23 31.3	+ 2 14	0.6	23 12.6	1 46	0.6	23 30.0	1 43	0.7
28.5										23 5.6	+ 1 54	0.4	23 22.3	2 4	0.5
Mar 8.5													23 14.9	+ 2 9	0.3

OBSERVATIONS OF COMETS,

MADE AT THE SCHOOL OF SCIENCE OBSERVATORY,

BY T. REED.

[Communicated by Professor Young.]

1892 Greenwich M.T.	✱	No. Comp.	☄ — ✱ Δα	☄ — ✱ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
Wolf's Periodic Comet.								
1892 h m s			m s	' "	h m s	° ' "		
Jan. 31 14 9 0	1	6	−1 20.52	+6 35.1	4 28 25.15	− 9 51 1.2	9.218	0.824
Feb. 17 14 27 33	2	6	−0 15.97	+7 38.8	4 45 6.17	− 6 59 26.7	9.419	0.798
14 25 26	3	7	−1 36.69	+1 14.6	4 45 5.88	− 6 59 25.8	9.412	0.798
Comet a 1892 (Swift).								
Sep. 25 13 11 23	4	5 , 1	−0 53.00	−2 4.7	0 10 21.78	+48 49 55.5	n9.695	9.409
28 15 26 6	5	2	+0 21.79	. . . .	0 6 48.10	. . . . .	n9.285	
15 49 36	5	6	. . . .	+0 3.0	. . . . .	+48 5 1.1	. . .	n0.052

Mean Places for 1892.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	4 29 45.46	+0.214	— 9 57 32.0	— 4.28	Paris 5276
2	4 45 22.12	+0.018	— 7 7 1.3	— 4.17	Schjellerup 1556
3	4 46 42.55	+0.024	— 7 0 16.3	— 4.12	Weisse's Bessel IV, 979
4	0 11 11.85	+2.935	+18 51 13.0	+17.21	Paris 221
5	0 6 23.24	+2.929	+18 4 40.6	+17.17	Bonn 17°22

The observations were made with the 9½-inch equatorial.

For Wolf's comet the square-bar micrometer was used; for Swift's the ring-micrometer.

RING-MICROMETER OBSERVATIONS OF COMET *f* 1892 (*HOLMES*).

MADE WITH THE RUTHERFURD 13-INCH EQUATORIAL OF COLUMBIA COLLEGE OBSERVATORY

BY J. K. REES AND HAROLD JACOBY.

1892 Col. College M.T.		✱	No. Comp.	☄ — ✱		☄'s apparent		log *p*Δ		Obs'r
				Δα	Δδ	α	δ	for α	for δ	
	h m s			s	′ ″	h m s	° ′ ″			
Nov. 16	10 20 51	1	5	. . . . . .	—2 25.1	. . . .	37 35 8.5	. . .	9.866	Rees
	10 25 6	1	7	—10.40	. . . . . .	0 43 0.74	. . . .	*n*9.329	. . .	Rees
20	6 5 5	2	3 , 3	+26.30	+6 58.2	0 12 16.80	37 9 53.5	*n*9.517	0.110	Rees
	6 17 17	2	3 , 3	+24.93	+6 58.5	0 12 15.13	37 9 53.8	*n*9.517	0.102	Jacoby

Mean Places for 1892.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 43 38.23	+2.94	37 36 56.9	+26.7	Paris, 1020
2	0 11 47.63	+2.87	37 2 28.3	+27.0	Weisse's Bessel, O 1029

Nov. 16. The comet appeared much fainter than on Nov. 11.

Nov. 20. The diameter of the coma appeared to be about 15′ in a north and south direction. The coma extended toward the west about 6′ from the nucleus, and toward the east about 12′. A faint tail was noticed on the east side. The nucleus was somewhat elongated in the east and west direction.

Mr. MONELL, Assistant in the Observatory, aided in the reductions of the above observations.

Columbia College Observatory, New York, 1892 *Nov.* 23.

RING-MICROMETER OBSERVATIONS OF COMET *f* 1892 (*HOLMES*).

MADE AT THE OBSERVATORY OF THE CATHOLIC UNIVERSITY OF AMERICA

BY REV. G. M. SEARLE.

1892 Greenwich M.T.		✱	No. Comp.	☄ — ✱		☄'s apparent		log *p*Δ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Nov. 10	21 9 21	1	1	+ 0 59.65	+ 0 39.0	0 45 8.46	+38 10 16.6	9.757	[illegible]
	21 9 21	2	4	+ 0 54.78	+ 2 22.5	0 45 8.54	+38 10 9.6	9.757	[illegible]
11	11 23 7	1	2	+ 0 40.30	— 3 1.5	0 44 19.31	+38 6 36.1	8.251	[illegible]
	.. .. ..	2	2	+ 0 35.24	— 1 23.2	0 44 19.00	+38 6 23.9	8.251	[illegible]
13	13 33 12	3	5	— 2 59.43	— 3 56.7	0 43 59.98	+37 54 14.2	8.935	[illegible]
16	13 52 46	4	3	+12 40.58	— 3 57.4	0 43 1.36	+37 35 56.2	8.181	[illegible]
	15 7 49	5	2	+10 18.99	+ 9 24.7	0 43 2.26	+37 35 26.0	9.241	[illegible]
18	13 36 38	5	1	+ 9 51.80	— 3 16.8	0 42 35.07	+37 22 44.5	8.181	9.240
24	13 51 27	6	1	— 5 28.03	+13 28.2	0 42 7.08	+37 3 56.2	8.570	[illegible]

Adopted Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 11 5.83	+ 2.98	+ 38 9 11.5	+ 26.1	Comparison with Yarnall 150
2	0 11 10.78	+ 2.98	+ 38 7 20.9	+ 26.2	Comparison with μ *Androm.* (Am. Ephem.)
3	0 16 56.13	+ 2.98	+ 37 57 11.5	+ 26.1	Yarnall 150
4	0 30 17.99	+ 2.79	+ 37 39 26.8	+ 26.8	Yarnall 281
5	0 32 10.47	+ 2.80	+ 37 25 31.3	+ 27.0	Yarnall 308
6	0 17 32.20	+ 2.91	+ 36 50 0.9	+ 27.1	Yarnall 456

COMET *g* 1892 (*BROOKS*),

Prof. Porter, of the Cincinnati Observatory, has communicated two late positions of this comet. The details of the observations will be given in the next number.

1892 Nov. 29, $17^h\ 36^m\ 23^s$ Cincin. M.T. $\alpha = 13^h\ 11^m\ 30^s.31$, $\delta = +17°\ 58'\ 39''.0$ $\log p.\Delta$ $n9.525$ 0.576
30, $17^h\ 31^m\ 23^s$ $13^h\ 13^m\ 16^s.35$ $18°\ 35'\ 59''.4$ $n9.531$ 0.569

Dr. Chandler has computed Elements and Ephemeris as follows:

Elements.

T = 1893 Jan. 7 67258 Gr. M.T.

$$\left.\begin{aligned}\omega &= 81°\ \ 7'\ \ 2''.6\\ \Omega &= 183\ \ 29\ \ 13\ .8\\ i &= 111\ \ 18\ \ \ 0\ .1\end{aligned}\right\}\ \text{Eq. Nov. 26.5}$$

log. q = 0.095111

Computed from positions Nov. 21, 22, 24, 29, 30, at Cambridge and Cincinnati. Deviation for middle place, (C—O) $\Delta\lambda\cos\beta$, $-11''$; $\Delta\beta$, $+3''$. In following ephemeris, brightness Nov. 19 = 1.

Ephemeris for Greenwich Midnight.

	App. α	App. δ	log Δ	Br.
	h m s	° ′		
1892 Dec. 7.5	13 26 17	+23 23	0.1155	1.79
11.5	13 36 20	27 7	.0764	2.21
15.5	13 48 49	31 38	0.0354	2.75
19.5	14 5 4	37 5	9.9937	3.41
23.5	14 27 22	43 34	.9538	4.18
27.5	15 0 24	50 56	.9191	5.30
31.5	15 51 38	+58 36	9.8939	5.66

NEW ASTEROID.

A communication from Prof. Kreutz gives notice that Dr. Wolf, at Heidelberg, had discovered upon his photographic plates of August another new planet, of the twelfth magnitude.

L. 1892 Aug. 23 $12^h\ 5^m\ 3^s$ Greenw. M.T. App. $\alpha = 23^h\ 23^m\ 53^s.53$ App. $\delta = -7°\ 3'\ 31''.9$
29 11 52 5 23 20 35 .68 −7 30 11 .9

The following names have been assigned to asteroids previously discovered:

311.	Charlois,	1891 June 11,	*Claudia*,	*A.J.* XI,	18
312.	Charlois,	Aug. 28,	*Pierretta*,	"	48
320.	Palisa,	Oct. 11,	*Katharina*,	"	64
325.	Wolf,	1892 Mar. 18,	*Heidelberga*,	"	160
326.	Palisa,	Mar. 19,	*Tamara*,	"	160
330.	Wolf,	Mar. 28,	*Ilmatar*,	"	168

NOTICE.

If any readers of the *Astronomical Journal* know of unpublished measures of the double star, 70 *Ophiuchi*, or of measures published in unusual places, I should be pleased to hear from them. To those who may be interested, I will send a list of the measures I have.

P.O. Drawer S, Hartford, Conn. A. D. RISTEEN.

CONTENTS.

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OBSERVATIONS OF *MARS* AND HIS SATELLITES.

MADE WITH THE 36-INCH EQUATORIAL,

BY W. W. CAMPBELL.

My observations of *Mars* at the opposition just passed were made between July 10 and August 17, and in connection with those made by other observers. While special attention was paid to the surface features of the planet, micrometer-observations of the satellites, of the south polar cap, and of the axes of *Mars*, were made whenever there was an opportunity.

The satellites were usually easily visible, and in observing them it was not found necessary to reduce the light of the planet. The observations of July 10 were made with reference to the estimated center of *Mars*, but the circumstances were very unfavorable, and the results are only approximate. The other measures of distances were referred either to the preceding or to the following limb, and were usually made by the method of double distances, though the reductions have been made on the basis of single distances. The observations have been corrected for differential refraction, for the observed semidiameter of the planet, and for phase. The results are given below. Comparisons with the *Nautical Almanac* places show that the corrections to the ephemerides are very small.

POSITION-ANGLES OF *Phobos*.

Pac. Standard Time 1892 d h m s	p °	Pac. Standard Time 1892 d h m s	p °
July 10 14 48 –	269.5	Aug. 7 9 20 4	273.03
14 52 –	268.3	9 20 54	273.13
14 53 –	268.2	9 21 42	272.83
14 55 –	268.3	9 22 13	272.73
July 27 12 50 8	266.90	Aug. 14 13 52 28	76.32
12 51 8	266.50	13 53 39	74.92
12 51 59	265.70	13 54 32	75.42
Aug. 2 9 41 2	93.93	13 55 25	75.72
9 42 3	94.23	Aug. 16 13 43 6	285.62
9 43 52	92.63	13 46 44	286.22
9 44 23	93.43	13 47 16	285.82
9 45 5	92.13	13 48 11	285.52
Aug. 7 9 19 25	273.33	13 49 8	285.02

POSITION-ANGLES OF *Deimos*.

Pac. Standard Time 1892 d h m s	p °	Pac. Standard Time 1892 d h m s	p °
July 27 14 14 16	281.37	Aug. 7 9 50 9	94.82
14 41 9	281.17	9 51 6	95.02
14 51 39	281.47	9 51 53	94.72
Aug. 2 10 14 5	88.92	Aug. 15 13 53 52	279.44
10 14 59	89.22	13 55 20	279.34
10 15 51	89.12	13 56 8	279.14
10 16 21	89.32	13 56 57	278.64
Aug. 7 9 49 27	95.22	13 57 58	278.74

DISTANCES OF *Phobos*.

Pacific Standard Time 1892 d h m s	Dist. from prec. limb	Dist. from foll. limb	Dist. from center
July 10 14 57 –	. .	. .	29.85
14 59 –	. .	. .	30.13
15 0 –	. .	. .	30.15
July 27 12 53 39	19.86	. .	32.44
12 54 57	19.61	. .	32.19
12 56 14	19.15	. .	31.73
12 58 21	18.69	. .	31.27
13 1 54	18.37	. .	30.95
13 3 14	18.10	. .	30.68
13 4 42	. .	44.03	31.35
13 6 21	. .	43.00	30.32
13 7 21	. .	42.07	29.39
13 8 27	. .	42.07	29.39
13 12 10	. .	41.20	28.52
13 12 46	. .	42.10	29.42
13 13 22	. .	41.45	28.77
13 14 1	. .	41.17	28.49
Aug. 2 9 47 59	. .	20.71	33.46
9 49 16	. .	20.83	33.58
9 50 38	. .	21.32	34.07
9 51 42	16.81	. .	34.06
9 52 14	16.46	. .	33.71
9 52 57	17.17	. .	34.42
9 54 30	16.85	. .	34.10
9 56 1	17.04	. .	34.29
9 56 47	16.81	. .	34.06
9 57 12	17.12	. .	34.37
9 58 1	17.07	. .	34.32
9 58 23	17.05	. .	34.30
9 59 18	. .	21.24	33.99
9 59 49	. .	21.57	34.32
10 2 38	. .	22.19	34.94
10 3 13	. .	21.93	34.68
10 6 35	. .	21.86	34.61
10 8 59	. .	22.05	34.80
10 9 41	. .	22.37	35.12
Aug. 7 9 21 [illegible]	16.13	. .	28.92
9 25 9	16.01	. .	28.80
9 26 44	15.31	. .	28.10
9 27 12	14.76	. .	[illegible]
9 28 5	15.21	. .	[illegible]
9 28 51	. .	40.68	[illegible]
9 29 47	. .	40.57	27.80
9 30 37	. .	40.07	27.28
9 31 27	. .	[illegible]	[illegible]
9 31 50	. .	[illegible]	[illegible]

Pacific Standard Time 1892	Dist. from prec. limb	Dist. from foll. limb	Dist. from center
d h m s	″	″	″
Aug. 7 9 32 28	. .	39.58	26.79
9 35 11	. .	38.06	25.27
9 35 45	. .	38.50	25.71
9 37 3	. .	38.20	25.41
9 40 15	. .	37.54	24.75
9 40 17	. .	36.96	24.17
9 41 33	.	36.82	24.03
9 44 6	10.12	. .	22.91
9 45 12	9.95	. .	22.71
9 45 43	10.10	. .	22.89
9 46 10	9.62	. .	22.41
9 46 37	10.05	. .	22.84
9 47 25	9.44	. .	22.23
9 47 45	9.53	. .	22.32
Aug. 14 13 57 16	. .	10.62	. .
13 58 3	. .	9.63	. .
13 58 29	. .	9.91	. .
13 58 49	. .	10.00	. .
13 59 18	33.76	. .	. .
14 0 15	33.72	. .	. .
14 1 17	34.30	. .	. .
Aug. 16 13 51 52	15.37	. .	27.71
13 52 42	14.83	. .	27.20
13 53 13	15.37	. .	27.74
13 54 23	15.51	. .	27.88
13 54 56	16.11	. .	28.48
13 55 37	16.46	. .	28.83
13 56 43	. .	40.99	28.80
13 57 17	. .	40.59	28.40
13 58 21	. .	40.79	28.60
13 58 46	. .	40.97	28.78
13 59 26	. .	41.18	28.99

The diameter of *Mars* was not measured on August 2; but the observations of that evening are satisfactorily reduced by using an assumed diameter 25″.50, obtained from the measures of August 7 by subtracting the computed change of diameter during the interval.

The observations of August 14 could not be completed on account of clouds; but a satisfactory reduction is made by taking the mean of the two sets of observations properly, and applying the correction —0″.07 for phase. Thus, at Pacific Standard Time August 14^d 13^h 59^m 23^s the corrected distance from the center was 21″.91.

DISTANCES OF *Deimos*.

Pacific Standard Time 1892	Dist. from prec. limb	Dist. from foll. limb	Dist. from center
d h m s	″	″	″
July 27 14 53 44	58.58	. .	71.16
14 55 9	58.23	. .	70.81
14 56 34	59.10	. .	71.68
14 58 24	60.17	. .	72.75
14 59 34	59.49	. .	72.07
15 0 24	59.69	. .	72.27
15 1 44	. .	84.90	72.22
15 2 54	. .	84.94	72.26
15 4 4	. .	85.00	72.32
15 6 1	. .	85.89	73.21
15 6 59	. .	85.26	72.58
15 7 39	. .	85.58	72.90
15 9 54	. .	85.49	72.81
Aug. 2 10 18 14	. .	72.33	85.08
10 18 51	. .	72.43	85.18
10 19 26	. .	72.67	85.42
10 20 40	98.51	. .	85.76
10 21 8	98.20	. .	85.45
10 21 29	97.97	. .	85.22
10 22 5	98.52	. .	85.77
10 23 19	98.55	. .	85.80
10 24 28	98.46	. .	85.71
10 24 59	97.88	. .	85.13
10 25 25	97.75	. .	85.00
10 26 5	. .	72.32	85.07
10 27 17	. .	72.33	85.08
10 27 36	. .	72.17	84.92
10 27 56	. .	72.27	85.02
Aug. 7 9 53 27	96.21	. .	83.42
9 54 16	95.77	. .	82.98
9 55 43	96.18	. .	83.39
9 56 17	96.57	. .	83.78
9 56 49	96.29	. .	83.50
9 57 49	. .	70.70	83.49
9 58 16	. .	71.39	84.18
9 58 38	. .	71.23	84.02
9 58 51	. .	71.19	83.98
9 59 31	. .	70.60	83.39
10 1 37	. .	71.17	83.96
10 2 23	. .	70.96	83.75
10 2 39	. .	71.32	84.11
10 3 3	. .	71.09	83.88
10 3 18	. .	71.11	83.90
10 3 51	. .	71.24	84.03
10 4 25	96.74	. .	83.95
10 5 12	96.71	. .	83.92
10 5 38	96.81	. .	84.02
10 6 5	96.54	. .	83.75
10 6 54	96.76	. .	83.97
10 7 15	96.66	. .	83.87
10 7 27	97.06	. .	84.27
Aug. 15 14 1 23	66.31	. .	78.70
14 2 3	66.01	. .	78.37
14 2 34	65.87	. .	78.23
14 3 10	66.34	. .	78.70
14 3 34	66.09	. .	78.45
14 4 9	. .	91.50	79.30
14 4 38	. .	91.43	79.23
14 5 13	. .	91.28	79.08
14 7 12	. .	91.40	79.20
14 8 41	. .	91.73	79.53
14 10 42	. .	92.40	80.20
14 11 26	. .	92.63	80.43
14 11 43	. .	92.38	80.18
14 12 2	. .	92.23	80.03
14 13 9	. .	92.27	80.07
14 13 40	68.13	. .	80.49
14 14 41	67.73	. .	80.09
14 15 15	67.45	. .	79.81
14 16 39	68.02	. .	80.38
14 17 18	67.93	. .	80.29

In reducing the observations of August 2, the assumed value of the diameter of *Mars*, 25″.50, was used, as in the case of the observations of *Phobos*.

ECLIPSE OF *Phobos*.

The disappearance of *Phobos* by eclipse was observed to occur suddenly at 1892 July 20^{d} 13^{h} 30^{m} 11^{s}, Pacific Standard Time.

DIAMETERS OF *Mars*.

The diameters of the planet were measured on several occasions by the method of double distances, principally for the purpose of obtaining the data required in the reductions. The results, corrected for differential refraction and for phase, are tabulated below. They are systematically about 1″.2 less than the values given in the *Nautical Almanac*, and about 0″.8 greater than the results of the best heliometer determinations.

Pacific Standard Time. 1892.		Polar Diameter	No. Obs.	Equatorial Diameter	No. Obs.
d	h	″		″	
July 20	15.2	24.36	3	24.62	3
21	12.8	24.79	3	24.95	3
27	12.5	25.10	3	25.36	3
30	13.3	25.37	3	25.24	3
31	13.4	25.22	3	25.34	3
7	10.4	25.52	3	25.52	3
7	11.8	25.59	5	25.70	5
15	13.8	. .	.	24.74	3
16	12.4	25.18	5	24.77	5
17	13.2	24.97	6	24.98	5

POSITION-ANGLES OF THE AXIS OF *Mars*.

The position-angles of the axis of *Mars* were estimated by two methods: (*a*) by passing the two micrometer wires through the extremities of the polar cap in such a direction that they cut equal segments from the two limbs of the planet; and (*b*) by placing the wire tangent to the northern edge of the polar cap and at right angles to the line drawn from the center of the cap to the center of the disk. The results are given in the table below. Compared with Marth's computed values, the average residual (observation — computation) is —0°.16.

Pacific Standard Time 1892		*p*	Meth.	Pacific Standard Time 1892		*p*	Meth.
d	h	°		d	h	°	
July 11	12.2	359.0	*a*	July 30	13.2	359.4	*a*
11	13.5	357.8	*a*	31	13.3	358.8	*b*
13	15.1	359.4	*a*	31	13.5	359.7	[illegible]
17	12.0	359.6	*a*	Aug. 7	10.2	1.6	*b*
18	12.6	358.3	*b*	7	10.3	0.3	*a*
18	12.7	1.0	*a*	16	12.0	2.6	[illegible]
20	15.0	358.8	*b*	16	12.5	3.6	[illegible]
24	12.7	358.0	*a*	17	12.8	3.1	[illegible]
July 30	13.0	357.7	*b*	Aug. 17	13.2	3.5	*a*

Mt. Hamilton, 1892 *November* 21.

OBSERVED MAXIMA OF LONG-PERIOD VARIABLES, WITH A CORRECTION TO THE PUBLISHED ELEMENTS OF *X HERCULIS*.

BY PAUL S. YENDELL.

5675 *V Coronae*.

Six observations of *V Coronae*, from 1892 May 27 to July 30, appear to indicate a maximum about July 11, the highest observed light being 8^{M}.2, on July 15. The time of maximum is uncertain, on account of a bad gap in the series, but the indications are that the maximum cannot have been later, nor many days earlier than the date given.

5770 *R Herculis*.

Twelve observations of this star, from 1892 April 23 to July 30, show a maximum to have been passed June 16; the star was quite faint, not rising, according to my estimates, above 9^{M}.0.

5950 *W Herculis*.

I have thirteen observations of *W Herculis*, from 1892 April 24 to August 13. These show a maximum of 8^{M}.2 to have occurred on June 24.

5955 *R Draconis*.

Fourteen observations, from 1892 July 15 to October 19. A maximum of 7^{M}.8 is indicated on September 30.

Dorchester, Mass., 1892 *Nov.* 19.

6819 *R Aquilae*.

From 1892 August 13 to September 25, I observed this star twenty times; a maximum of 6^{M}.3 is indicated on August 19, followed by a secondary maximum of 6^{M}.4 on September 8, the star having fallen during the interval to 7^{M}.5.

7431 *S Delphini*.

I have twenty-five observations of *S Delphini*, from 1892 July 17 to November 8; these indicate that a maximum occurred about August 26, though from the extreme flatness of the light-curve, the date is difficult to determine with exactness, and may have been as late as September 1.

7560 *R Vulpeculae*.

Nineteen observations, from 1892 July 17 to October 19, show a well-defined maximum of 8^{M}.1 on September 1; the star's light had fallen to 9^{M}.0 when last observed.

CORRECTION TO THE ELEMENTS OF *X Herculis*.

The writer desires to call attention to an error of transcription occurring in his elements of *X Herculis*, published in this Journal, on page 90 of the current volume, by which the date of the principal Epoch of Maximum is given as 1890 June 22.7; this should read 1890 June 2[illegible]6.

RING-MICROMETER OBSERVATIONS OF COMETS,

MADE AT THE OBSERVATORY OF THE CATHOLIC UNIVERSITY OF AMERICA.

By Rev. G. M. SEARLE.

1892 Greenwich M.T.		*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
				Comet *a* 1892 (Swift).					
	h m s			m s	′ ″	h m s	° ′ ″		
Mar. 10	22 10 4	1	7	— 0 21.9	— 5 11	19 17 23.5	—28 9 45	*n*9.564	0.858
14	21 44 12	2	6	— 1 6.7	— 5 54	19 22 3.9	—27 18 21	*n*9.602	0.839
21	22 3 57	3	2	+ 6 26.0	—13 54	20 7 17.8	—17 44 20	*n*9.551	0.825
28	21 34 12	4	1	— 3 26.0	+ 3 40	20 36 22.5	—10 27 44	*n*9.584	0.789
Apr. 9	20 51 49	5	3	— 2 45.3	+ 4 0	21 21 59.9	+ 2 2 12	*n*9.622	0.734
	" " "	6	4	— 3 18.5	+ 2 36	21 24 59.8	+ 2 2 45	*n*9.622	0.734
11	20 57 13	7	5	+ 1 26.0	— 2 9	21 29 32.3	+ 1 5 14	*n*9.617	0.724
22	20 38 36	8	5	+ 1 24.1	+ 3 5	22 6 30.8	+14 8 50	*n*9.640	0.673
May 1	20 5 36	9	5	— 0 28.4	— 3 4	22 43 31.6	+23 16 12	*n*9.679	0.634
5	20 22 0	10	8	+ 1 44.5	— 4 51	22 46 30.9	+23 56 49	*n*9.670	0.605
				Comet *d* 1892 (Brooks.)					
Sep. 16	20 52 36	11	5	— 1 1.22	— 1 24.0	6 18 16.86	+29 38 26.9	*n*9.589	0.397
	21 5 18	12	3	+ 1 29.67	— 0 29.0	6 18 17.63	+29 38 29.7	*n*9.565	0.373
23	20 52 18	13	3	— 1 26.30	+11 25.5	7 7 47.89	+28 16 35.3	*n*9.569	0.410
28	20 43 42	14	3	— 6 58.13	— 3 54.0	7 22 19.76	+27 4 20.3	*n*9.570	0.439
Oct. 16	21 10 55	15	5	— 3 37.24	—12 3.3	8 19 37.25	+20 35 13.8	*n*9.457	0.507

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	19 17 46.15	— 0.73	— 28 4 25.8	— 5.6	Arg. Gen. Cat. 26570
2	19 23 11.33	— 0.78	— 27 12 21.1	— 6.1	" " " 26682 pr.
3	20 0 52.50	— 0.65	— 17 30 17.8	— 8.7	Lamont 22989
4	20 39 49.48	— 0.64	— 10 30 44.1	— 10.2	Yarnall 9274
5	21 24 45.84	— 0.59	+ 1 58 54.0	— 12.2	Albany Zones 7519
6	21 25 18.86	— 0.59	+ 2 0 21.0	— 12.2	" " 7523
7	21 28 6.90	— 0.58	+ 1 7 34.4	— 12.4	" " 7537
8	22 5 7.27	— 0.54	+ 14 5 57.3	— 13.2	Glasgow 5747
9	22 44 3.48	— 0.51	+ 23 19 29.1	— 13.1	Weisse's Bessel XXII, 986, 987
10	22 44 46.89	— 0.50	+ 24 1 53.7	— 13.0	Yarnall (*μ Pegasi*)
11	6 49 16.53	+ 1.55	+ 29 39 17.0	+ 3.4	Weisse's Bessel VI, 1395
12	6 16 46.39	+ 1.57	+ 29 38 55.1	+ 3.6	" " " 1347
13	7 9 12.57	+ 1.62	+ 28 5 6.9	+ 2.9	Yarnall (53 *Geminorum*)
14	7 29 16.22	+ 1.67	+ 27 8 12.4	+ 1.9	Yarnall (*ο Geminorum*)
15	8 23 12.63	+ 1.86	+ 20 47 17.3	— 0.2	Yarnall 3486

REPORTS OF THE PARTIAL ECLIPSE OF THE SUN OF 1892 OCTOBER 20.

[Transmitted by Capt. F. V. McNair, Superintendent, Naval Observatory, Washington, D.C.]

The following observations of the partial eclipse of the sun of 1892 October 20, have been received at the Naval Observatory, in response to a circular requesting that observations of the above phenomena be made and forwarded.

Prof. Frisby has collated these reports, as shown in the following table, and has also computed the Greenwich mean time of first and last contact at each station from which reports have been received. The difference between the observed and the computed times of contact is shown in the column headed O—C.

No.	Observer	Station	Latitude	Longit.	Diam obj.	Power used	Observed time first cont.	Computed time first cont.	O−C	Obs. second cont.	Comp. time second cont.	O−C
1	R. L. Hoxie	Willet's Pt. N.Y.	40 47 22	73 46 55	5.5	96	5 6 12.9	5 6 0.6	+12.3	8 7 9.0	8 7 [illegible]	[illegible]
2	Miss Whitney	Vassar Coll. Obs.	41 41 18	73 53 24	12	100	5 5 17.6	5 4 13.3	+64.3	8 5 8.2	8 5 21.1	[illegible]
3	Miss Grant	" " "	41 41 18	73 53 24	6	60	5 4 40.6	5 4 13.3	+27.3	8 5 18.3	8 5 21.1	−2.8
4	Miss Bartlett	" " "	41 41 18	73 53 24	3	60	. . .	. . .	.	8 5 0.3	8 5 21.1	−20.8
5	J. E. Kershner	Lancaster, Pa.	40 3	76 19 15	11	187	5 4 19.7	5 4 1.8	+17.9	8 4 49.9	8 4 44.5	+5.4
6	Justin Stahn	Baltimore, Md.	39 17 18	76 36 15	–	–	5 5 12.0	5 5 5.8	+6.2	8 5 45.0	8 5 51.8	−6.8
7	Rev. G. M. Searle	Catholic Univ.	38 56 15	77 0 0	9	50	5 5 31.0	5 5 23.8	+7.2	8 5 45.0	8 5 54.1	−9.1
8	H. L. Baldwin	Geol. Sur. Office	38 53 10	77 2	1.2	40	5 5 30.0	5 5 25.0	+5.0	8 5 57.3	8 5 55.3	+2.0
9	Prof. E. Frisby	Old Naval Obs.	38 53 39	77 3 6	4	175	5 5 35.8	5 5 23.4	+12.1	8 6 0.6	8 5 53.9	+6.7
10	Prof. Wm. Harkness	New Naval Obs.	38 55 18	77 4	3	[illegible]	5 5 25.8	5 5 18.9	+6.9	8 5 47.8	8 5 49.3	−1.5
11	Prof. J. R. Eastman	New Naval Obs.	38 55 18	77 4	3.25	100	5 5 22.1	5 5 18.9	+3.2	8 5 48.6	8 5 49.3	−0.7
12	Geo. A. Hill	Georgetown H'ts	38 55 48	77 4 30	3	90	5 5 41.1	5 5 18.6	+22.5	8 5 1.2	8 5 47.5	−46.3
13	Rev. J. G. Hagen	Georget'n Coll. Obs.	38 54 26	77 4 34	5	100	5 5 31.7	5 5 20.2	+11.5	8 5 45.0	8 5 50.3	−5.3
14	E. L. Allar	Ann Arbor, Mich.	42 16 47	83 43 47	6	80	4 52 10.3	4 51 51.0	+19.3	. . .	. . .	. .

(1) First possibly 2 or 3 seconds late; last 1 second late.
(2) First contact 1 minute late.
(8) Both contacts probably 2 seconds late.
(9) 26-inch reduced to 4 inches. First contact uncertain.
(12) 5-inch reduced to 3 inches. First contact 3 seconds late.
(14) Clouds at time of last contact.

OBSERVATIONS OF THE SOLAR ECLIPSE OF OCT. 19–20,

MADE AT THE WASHBURN OBSERVATORY.

BY GEORGE C. COMSTOCK.

The first contact of the eclipse was observed by myself with the 40 cm. equatorial, provided with a Herschelian eyepiece carrying a filar-micrometer. Mr. A. S. Flint observed the contact with the smaller Clark equatorial of 15 cm. aperture, also provided with a Herschelian eyepiece. The full aperture of both telescopes was employed. The morning was clear but clouds gathered shortly before the predicted time of first contact and completely obscured the sun within a very few minutes after the contact. The seeing at the instant of contact was fairly good.

Observer	Power	Madison M. T.	Remarks
C.	196	22 48 18.5	[illegible]
F.	176	22 48 27.0	[illegible]

Immediately after recording the time of contact I measured the position-angle of the advancing limb of the moon by placing the micrometer-thread tangent to it and found $p = 340^\circ.3$. The computed position-angle and time of first contact were $p = 340^\circ.6$, $T = 22^h\ 48^m\ 11^s$.

OBSERVATION OF THE SOLAR ECLIPSE OF 1892 OCTOBER 20,

MADE AT THE JOHNS HOPKINS UNIVERSITY, BALTIMORE. Latitude 39° 17′ 48″ N. Longitude [illegible] W.

Communicated by Prof. NEWCOMB.

Observation with 10-inch equatorial:

	Beginning	Ending
Chronometer time,	12 1 25.0 N	3 2 1.0 P
Correction,	−2 38.9	−2 38.3
Local mean time,	23 58 46.1	2 59 22.7
Greenwich mean time,	5 5 12.1	8 5 48.7

Observation with alt-azimuth (aperture [illegible]):

	Beginning	Ending
Chronometer time,	12 1 22.0 P	[illegible] A
Correction,	2 38.9	2 [illegible]
Local mean time,	23 58 [illegible]	[illegible]
Greenwich mean time,	12 5 16.1	[illegible] 42.7

N. = Prof. NEWCOMB. P = Dr. POOR. A = Mr. ANNIS.

OBSERVATIONS OF COMET *d* 1892 (*BROOKS*),

MADE AT THE BOSTON UNIVERSITY OBSERVATORY.

By J. B. COIT.

1892 Washington M.T.		*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Oct. 21	15 13 12.2	1	13 , 4	—0 7.30	—0 13.2	8 17 52.91	+16 20 23.8	*n*9.427	0.623
28	14 57 26.3	2	9 , 3	—0 54.60	+2 37.8	9 2 42.55	+13 50 16.9	*n*9.518	0.671
	16 0 22.0	2	7 , 2	—0 44.61	+0 52.1	9 2 52.54	+13 18 31.5	*n*9.370	0.646
	16 4 54.2	3	7	+0 19.50	. . . .	9 2 53.03	. . . .	*n*9.356	. . .

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	8 17 58.32	+1.89	+16 20 38.1	—1.1	Weisse's Bessel VIII. 1140
2	9 3 35.26	+1.89	+13 17 40.8	—1.7	" " 1552
3	9 2 34.63	+1.90	+13 39 32.3	—1.5	" " 1528

OBSERVATIONS OF COMETS,

MADE AT THE HARVARD COLLEGE OBSERVATORY.

By O. C. WENDELL, Assistant.

[Communicated by Professor E. C. Pickering, Director.]

1892 Cambridge M.T.		*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
				Comet *f* 1892 (Holmes).					
	h m s			m s	′ ″	h m s	° ′ ″		
Nov. 14	7 50 12	1	1	—3 21.25	— 9 58.9	0 43 37.94	+37 48 18.4	*n*9.249	9.948
16	14 52 23	2	5	—0 43.95	— 3 33.0	0 42 56.41	+37 33 52.1	9.741	0.668
17	7 59 38	2	5	—0 55.33	— 7 58.7	0 42 45.03	+37 29 26.5	*n*9.100	9.917
19	10 13 26	3	8	—2 9.74	+ 2 2.0	0 42 21.75	+37 13 4.3	9.437	0.114
20	13 55 33	4	10	+0 21.90	+ 1 45.4	0 42 12.32	+37 7 40.7	9.730	0.602
22	8 11 29	4	8	+0 11.66	— 5 22.6	0 42 2.06	+36 57 33.0	*n*8.695	9.906
23	7 56 50	4	7	+0 9.88	—11 33.6	0 42 0.27	+36 51 22.1	*n*8.865	9.933
	10 42 41	4	10	+0 9.64	—12 20.3	0 42 0.03	+36 50 35.4	9.473	0.172
				Comet *g* 1892 (Brooks).					
Nov. 21	16 41 38	5	5	—0 58.45	+ 2 27.8	12 59 15.62	+13 50 27.3	*n*9.598	0.701
22	16 22 45	6	5	—0 15.90	+15 26.1	13 0 36.26	+14 16 18.4	*n*9.618	0.718
24	16 19 10	7	6	+3 18.68	— 5 27.4	13 3 29.05	+15 12 34.9	*n*9.616	0.703

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 46 56.23	+2.96	+37 57 50.8	+26.5	Lalande 1143
2	0 43 37.16	+2.90	+37 36 58.4	+26.7 +26.8	" 1323
3	0 44 28.71	+2.78	+37 10 34.7	+27.6	B.B. VI, 36°134
4	0 41 47.55	+2.87 +2.84	+37 2 28.2	+27.1 +27.5	W.Bessel O 1029
5	13 0 12.89	+1.18	+13 48 13.9	—14.4	W.Bessel XII. 1004
6	13 0 50.95	+1.21	+14 1 7.0	—14.7	" " 1014
7	13 0 9.10	+1.27	+15 18 17.9	—15.6	Lalande 24330

OBSERVATIONS OF COMET *f* 1892 (*HOLMES*),

MADE AT GOODSELL OBSERVATORY, NORTHFIELD, MINN., WITH THE 16-INCH REFRACTOR AND FILAR MICROMETER

By H. C. WILSON.

[Communicated by WM. W. PAYNE, Director.]

1892 Northfield M.T.	✱	No. Comp.	☄ – ✱ Δα	☄ – ✱ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
			m s	′ ″	h m s	° ′ ″		
Nov. 11 11 0 15	1	9 , 6	−2 11.28	+7 15.2	0 44 45.03	+38 5 25.4	9.366	0.126
15 9 4 50	2	6 , 4	−0 23.40	+3 56.0	0 43 17.09	+37 41 21.1	7.987	0.065
18 9 43 56	3	9 , 6	−2 17.19	−5 35.0	0 42 32.15	+37 22 24.7	9.108	0.070
22 9 34 14	4	6 , 4	−5 32.00	+6 20.3	0 42 3.23	+36 56 47.8	9.153	0.102

Mean Places for 1892.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 46 56.31	+3.00	+37 57 44.1	+26.1	Yarnall-Frisby 150; Armagh 126
2	0 43 37.57	+2.92	+37 36 58.5	+26.6	Lalande 1323
3	0 45 16.42	+2.92	+37 27 32.8	+26.9	Lalande 1384
4	0 47 32.33	+2.90	+36 50 0.3	+27.2	Yarnall-Frisby, 156

OBSERVATIONS OF COMET *f* 1892 (*HOLMES*),

MADE AT THE DUDLEY OBSERVATORY, ALBANY.

BY LEWIS BOSS.

1892 Albany M.T.	✱	No. Comp.	☄ – ✱ Δα	☄ – ✱ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
			m s	′ ″	h m s	° ′ ″		
Nov. 17 7 56 12	1	16 , 7	−2 32.92	+1 37.4	0 42 46.78	+37 29 24.9	n9.1255	9.9479
22 7 21 30	2	10 , 10	+0 13.05	−5 21.2	0 42 3.79	+36 57 32.7	n9.2000	0.0083

Mean Place for 1892.0 of Comparison-Stars.

✱	α	Reduction	δ	Reduction	Authority
	h m s	s	° ′ ″	″	
1	0 45 16.79	+2.91	+37 27 20.8	+26.7	(Lal. 1381): Paris, 2 obs. Lund 2 obs.
2	0 41 47.88	+2.86	+37 2 29.6	+27.3	(W.B. O.1029); Lund 1 obs.

The central condensation appeared fainter, both on Nov. 17 and 22 than on Nov. 13, and was observed with difficulty under faintly illuminated wires. The surrounding nebulosity, which appeared exceedingly transparent on the two later dates, was estimated to be about 10′ in diameter on Nov. 17, and 8′ on Nov. 22. Yet it still appeared to be remarkably definite on the north preceding edge and, for that part, concentric with the central condensation. On Nov. 17, as my notes with diagram show, the outer nebulosity appeared to be very defective on the south following quarter and to extend not more than two or three minutes from the nucleus condensation, with faint streamers 5′ or 6′ in length bounding the void on either side. On Nov. 22, a very faint extension of the nebulosity was noticed in position-angle 120°. This appendage or tail could be traced to about 12′ from the nucleus and was, perhaps, 8′ in breadth.

On Nov. 18, I computed parabolic elements which now possess no interest, and on the following day, as the result of a first approximation, the following elliptic elements:

$$T = 1892, \text{ June } 7.0966, \text{ G.M.T.}$$

$$\left.\begin{array}{ll} \omega = & 8\ 35\ 11 \\ \Omega = & 333\ \ 8\ \ [illegible] \\ i = & 20\ 52\ 52 \end{array}\right\} \text{Apparent Equinox.}$$

$$\log a = 0.558760$$

$$\log e = 9.632501$$

Subsequent approximations, while improving the representation of the observation of Nov. 13, did not so well represent that of Nov. 22 as did the above; which gives a periodic time of 6y.89 and indicates a close approach to *Jupiter* in 1861. On Nov. 24, the correction to an ephemeris founded on these elements appears to be: Δα = [illegible] 3s.7, Δδ = [illegible] 8′. The comet was found to be too faint to permit of observation in bright moonlight, Dec. 2.

COMET *f* 1892 (*HOLMES*).

BY REV. G. M. SEARLE.

I have computed a new set of elements from the observations of Nov. 8 and 16, with one made elsewhere on Nov. 21; but a correction having been subsequently sent to the latter, which would make a considerable change, it is perhaps hardly worth while to publish them. The period is 6¾ years. They give the perihelion passage in August; this element, and the perihelion longitude, are very indeterminate. And the other root to the distance-equation is perhaps still admissible.

The comet on Nov. 29 was merely a faint and vague wisp of nebula; no observation was possible, as no nucleus could be sighted on. In case of an improvement, or for larger instruments, the following ephemeris, from the new elements, will probably be better than one made from the former ones.

1892 *December* 3.

EPHEMERIS FOR GREENWICH MIDNIGHT.

Gr. M.T.	α (h m s)	δ (° ′)	log Δ	Br.
Dec. 9.5	0 45 51	+35 15.7	0.2597	0.68
13.5	48 9	34 55.5	0.2702	.64
17.5	50 50	34 37.1	0.2809	.61
21.5	0 53 58	+34 21.0	0.2918	0.57

OBSERVATIONS OF COMET *g* 1892.

MADE AT THE CINCINNATI OBSERVATORY.

BY J. G. PORTER.

1892 Cincinnati M.T. (h m s)	⁎	☄ — ⁎ $\Delta\alpha$ (m s)	☄ — ⁎ $\Delta\delta$ (′ ″)	☄'s apparent α (h m s)	☄'s apparent δ (° ′ ″)	log $p\Delta$ for α	log $p\Delta$ for δ
Nov. 29 17 36 23	1	+0 16.62	+6 47.7	13 11 30.31	+17 58 39.0	*n*9.525	0.576
30 17 31 23	2	—1 14.46	—8 25.9	13 13 16.35	+18 35 59.4	*n*9.531	0.569

Mean Places for 1892.0 of Comparison-Stars.

⁎	α (h m s)	Reduction (s)	δ (° ′ ″)	Reduction (″)	Authority
1	13 11 12.36	+1.33	+17 52 8.8	—17.5	W.B. XIII, 165
2	13 11 29.18	+1.33	+18 41 43.3	—18.0	BB. VI, +18°2714

NEW ASTEROIDS.

Prof. KREUTZ writes, Nov. 24, that the small planet 1892 *L* had been observed at Vienna by PALISA.

Nov. 22, $5^h\ 49^m\ 6^s$ Vienna M.T. $\alpha = 341°\ 12'\ 35''$, $\delta = -10°\ 10'\ 50''$.

Daily motion, +5′ in α, and 2′ northward. Mag. 13.

He also sends notice of two others.

M. An asteroid, $11\frac{1}{2}^{\rm M}$, was photographed by CHARLOIS Nov. 15 and 16, and observed by him at Nice.

Nov. 20, $6^h\ 31^m.7$ Nice M.T. $\alpha = 33°\ 7'\ 6''$, $\delta = +10°\ 2'\ 9''$. Daily motion, —11′ in α, and 2′ northward.

N. Mr. BERBERICH announces one photographed by WOLF at Heidelberg, as follows:

Nov. 15, $8^h\ 37^m$ Greenwich M.T. $\alpha = 4^h\ 10^m.6$, $\delta = +23°\ 36'$.
20, $11^h\ 16^m$ " " $4^h\ 5^m.5$, $+23°\ 37'$.

CORRIGENDA.

Vol. XI, no. 254, p. 111, App. place of Comet *c* 1891 *for* $7^h\ 27^m\ 0^s.42$ *put* $7^h\ 37^m\ 0^s.42$

No. 277, p. 102, Obs. Oct. 19. *for* $\Delta\delta + 8'\ 30''.6$, $\delta = +10°\ 17'\ 26''.5$, *put* $\Delta\delta = +7'\ 30''.6$, $\delta = +10°\ 16'\ 26''.5$

Miss WHITNEY calls attention to an unpublished misprint in WEISSE'S reduction of BESSEL'S Northern Zones:
W.B. 0 1029, precession in R.A. *for* $3^s.135$ *put* $3^s.235$

CONTENTS.

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METEOR-SHOWER OF 1892 NOVEMBER 23.

By J. K. REES.

This evening I counted 199 meteors. They fell between the times $10^h\ 20^m$ and $11^h\ 5^m$. In the half hour between $10^h\ 20^m$ and $10^h\ 50^m$, I counted 165 meteors. At $10^h\ 50^m$, the clouds which had formed in the northwest began to obscure all parts of the sky except the eastern portion where *Orion* blazed. In this last named region most of the meteors were seen after $10^h\ 50^m$.

At $11^h\ 5^m$ the clouds prevented further observations. The radiant point appeared to me to be about 10° east and 5° north of the comet *f* 1892.

The meteor-trains were most frequently short, about 3° in length, and the heads appeared about as bright as second magnitude stars.

Some trains, notably of a few meteors falling near *Jupiter*, and of others traversing *Orion*, were extended to 25°, and the heads were as bright as *Mars*.

All the meteors were very quick movers, lasting in most cases a fraction (say [illegible]) of a second. A curious feature of the fall, as it appeared to me, was the explosion in groups. No meteors would be seen for a few minutes, then one could count five or more falling almost at the same time in the same portion of the sky. After the clouds began to come up, I counted quite a number of meteors through the clouds. I think the shower would have been a brilliant one in an unclouded sky. These meteors may be connected with the Biela-comet.

My place of observation was on the great flat roof of the Dakota (8th avenue and 72d street), New York City.

Columbia College, 1892 *November* 23.

METEOR-SHOWER OF 1892 NOVEMBER 23.

By J. G. HAGEN.

This meteor-shower was watched here until after midnight. As regards the general features of the phenomenon, the shooting stars were seen in all parts of the sky, apparently radiating from the neighborhood of the nebula in *Andromeda*, and comet *f* (Holmes) near the zenith. Only a few meteors were noticed whose direction seemed at variance with the general radiating point.

A great number of faint and short trails were seen to cross in all directions, the neighborhood of the radiating point within a circle of about ten degrees.

All magnitudes were represented, from the first to the faintest, some as bright as *Jupiter*.

There were more meteors from the zenith towards the West than towards the East. Not unfrequently five or more shooting stars appeared simultaneously.

The following table, prepared by Father Algué, will give some idea of the frequency of the meteors:

Greenwich M. T.				Algué look'g W.	Hagen look'g E.
From	11 27	to	11 32	12	
"	32	. . . .	37	22	
"	37	. . . .	42	2[illegible]	
"	42	. . . .	47	1[illegible]	
"	47	. . . .	52	18	2[illegible]
"	11 52	. . . .	57	[illegible]	20
From	11 27	"	11 57	188	

The [illegible] of the observatory [illegible] third of the visible sky. Hence one [illegible] W[illegible] must have seen about 250 meteors [illegible] between ten o'clock and [illegible]

The density of the shower [illegible] midnight, when it slightly decreased.

The following night [illegible]

Georgetown College, 1892 *November* 26.

THE METEOR-SHOWER OF 1892 NOVEMBER 23.

By EDWIN F. SAWYER.

While engaged upon my regular variable-star work on the evening of November 23, my attention was soon attracted to the unusual number of meteors falling. Suspecting that they might represent the forerunners of the so-called Biela-meteors, due about Nov. 27, a watch was at once begun. While attention was given at intervals to recording the intensity of the display, the chief attention was directed to noting and mapping those meteor-paths which were well observed, and especially the short paths near the radiant point, for the purpose of determining this radiant center as accurately as possible. From 7h 30m to 8h, 49 meteors were counted, 47 of these apparently radiating from the same center, near *γ Andromedae*. This would give for one observer, allowing for time spent in mapping tracks, about 125 per hour.

The meteors generally came in clusters, 4 or 5 being seen, at short intervals, almost simultaneously. Special outbursts were occasionally noticeable. At 7h 35m, 22 were observed in 3 minutes, and at 9h, 17 were counted in 2 minutes. At 10h 45m, 12 were observed in less than one minute.

Clouds interfered with the observations shortly after 9h, and shortly after 11h, the sky became almost completely overcast, and observations were discontinued. The hourly rate apparently increased up to 9h, when meteors were falling at the rate of about 300 per hour for one observer. At 11h, the rate had fallen to about 200 per hour, 51 being counted from 10h 45m to 11h.

The meteors were slow-moving, generally quite bright, although none were observed as bright as the planets *Mars* or *Jupiter*, and had short paths.

Twenty-five paths were quite accurately observed and mapped, from which the radiant-point has been determined. This point appeared slightly west of *γ Andromedae* or at R.A. 25°, Decl. +41°. The shower appeared shortlived, as only one or two were observed on the following nights, Nov. 24, 25 and 26, and on the 27th, although generally overcast, a careful inspection of a clear space in the northwest, shortly after dark, or from 5h 30m to 5h 45m, failed to reveal a single meteor. The observations were made at Brighton, Mass., the center of observation being at *γ Andromedae*.

Sky completely overcast on Nov. 28, 29 and 30 and December 1.

METEOR TRACKS MAPPED.

No.	Boston M.T.	Mag.	Observed Path				Length of Path	Wt.	Remarks
			From		To				
			R.A.	Decl.	R.A.	Decl.			
	h m		°	°	°	°			
1	7 50	3	26	+20	25½	+16	4	1	From near *β Arietis*
2	7 57	4	22½	40½	19	40½	3	4	Quite short; near radiant
3	8 4	1	21½	22	21	19	3	3	" "
4	8 6	2	31	42½	32½	43	1	4	Very short
5	8 8	4	31½	42	33	42½	1	4	" "
6	8 12	3	26	33	26	31½	2	4	" "
7	8 15	3	26	31	26	29½	2	4	" "
8	8 20	1	10	44¼	357	42	10	4	Rather long path
9	8 22	2	35	40½	40	41	4	3	Short
10	8 27	3	25	49	26½	53	4	3	"
11	8 40	3	46	48½	55	50½	6	4	Across *α Persei*
12	8 58	2	31¼	35	32½	32	4	4	Across *β* and *γ Trianguli*
13	8 59	3	23	47	21	49	3	3	Short
14	9 5	2	26	28	26½	24	7	4	
15	9 7	4	27	32½	27¼	31	1	4	Very short
16	9 13	3	27	41	27½	41	½	4	Nearly stationary; ended near *γ Andromedae*
17	9 18	>1	15	37	11	34½	5	4	
18	9 23	2	37½	30	41	27	5	3	
19	9 25	2	12	40½	4	40½	6	4	
20	9 27	2	30	22½	31½	18	5	4	From *α Arietis*
21	9 47	2	55	47½	67	48	10	4	
22	10 47	>1	163	65	176	56	10	3	Ended near *γ Ursae Majoris*
23	10 55	1	49	24	59	16	9	4	From *η Tauri*
24	11 7	3	55	24	60	19	6	4	From *Pleiades*
25	11 13	>1	79	6½	85	2	8	4	From *γ Orionis*

In the column of weights, 4 indicates an accurate observation, 1 a poor one.

Brighton, 1892 *December* 1.

THE PROPER MOTIONS OF THE STARS.

By W. H. S. MONCK.

I noticed some time ago a remarkable connection between the proper motions of the stars and their spectra — the solar stars (SECCHI's type II) having much greater proper motion than the Sirian stars (type I), or the stars of the third type, although the smaller number of the latter render the test less decisive. I may, however, add that stars with the kind of spectrum designated K in the Draper Catalogue (which though referred in that Catalogue to the second type border closely on the third) appear to have less proper motion than the other stars with the second type of spectrum. I lately compared Mr. PORTER's list of stars w[illegible] had a second and upwards, in the As[illegible] June 13, with the Draper Catalogue, and [illegible] worth publication. A large number, consisting [illegible] Southern stars, are not in the Draper Catalogue. My list contains all those which I succeeded in identifying. A signifies a spectrum of the first type (Sirian), E, F, G, H, I and K denote various forms of the second type (solar), while the third type is designated by the letter M.

Star	Proper motion	Spectrum	Star	Proper motion	Spectrum	Star	Proper motion	Spectrum
β *Cassiopeae*	0.51	F	Piazzi VII. 321	0.82	E	5 *Serpentis*	0.65	F
Piazzi O. 137	0.79	H	Lalande 16304	1.03	E	χ *Herculis*	0.75	F
54 *Piscium*	0.61	H	ρ *Cancri*	0.55	H	γ *Serpentis*	1.32	F
Lalande 1065, 6	0.79	H	ι *Ursae Majoris*	0.51	A	49 *Librae*	0.77	F
η *Cassiopeae*	1.19	F	10 *Ursae Majoris*	0.52	F	ρ *Coronae Borealis*	0.81	F
Mayer 20	1.37	H?	π *Cancri*	0.60	H	18 *Scorpii*	0.55	F
μ *Cassiopeae*	3.73	H	Fedorenko 1457, 8	1.69	H	ζ *Herculis*	0.62	G
Lalande 2450	0.57	H	Lalande 18286	0.52	E	36 *Ophiuchi*	1.24	I
41 (II.) *Andromedae*	0.82	F	Lalande 18397	0.55	H	ω *Herculis*	1.06	E
107 *Piscium*	0.73	F	θ *Ursae Majoris*	1.11	F	Fedorenko 2895	0.52	H
T Ceti	1.95	G?	11 *Leonis minoris*	0.77	H	26 *Draconis*	0.56	F
Piazzi I. 159	0.62	G?	20 *Leonis minoris*	0.69	A?	μ *Herculis*	0.81	F
Lalande 3922, 3	0.50	A	Groombridge 1618	1.45	H	70 *Ophiuchi*	1.13	K
Lalande 4141	0.60	A	Weisse-Bessel X. 520	0.71	F	μ *Serpentis*	0.91	K
δ *Trianguli*	1.15	F	α *Crateris*	0.50	I?	χ *Draconis*	0.63	F
Lalande 4855	0.60	H	ξ *Ursae Majoris*	0.74	G	Groombridge 2789	0.62	H
Piazzi II. 123	2.34	H	Piazzi XI. 32	0.79	H?	*b Aquilae*	0.96	H
ι *Persei*	1.25	F	83 *Leonis*	0.75	I	Bradley 2459	0.66	H
12 *Eridani*	0.73	F	Groombridge 1812	0.63	F	σ *Draconis*	1.8[illegible]	F
ε *Eridani*	1.01	K	β *Leonis*	0.53	A	[illegible]	0.64	A
10 *Tauri*	0.55	F	β *Virginis*	0.77	G	Lalande 38380	0.86	H
δ *Eridani*	0.75	I	Lalande 22585	0.50	E	15 *Sagittae*	0.58	F
τ⁶ *Eridani*	0.56	F	Lalande 22951-68	1.03	E	Groombridge 3150	0.57	F
40 *Eridani*	1.11	H?	8 *Canum venaticorum*	0.77	F	η *Cephei*	0.82	K
Groombridge 881	0.68	A	γ *Virginis*	0.57	F	61 *Cygni*	[illegible]	H
m Tauri	0.53	E	33 *Virginis*	0.52	H	Lalande 43492	0.84	A
λ *Aurigae*	0.84	F	δ *Virginis*	0.50	M	ζ *Pegasi*	[illegible]	F
Piazzi V. 146	0.55	I	Lalande 24111-6	0.72	H	σ *Pegasi*	[illegible]	I
δ *Leporis*	0.69	I	43 *Comae Berenices*	1.20	F	Bradley 3077	2.08	H
23 (II.) *Camelopardalis*	0.66	F	61 *Virginis*	1.51	H	[illegible]	[illegible]	I
Sirius	1.31	A?	W. Bessel XIII. 241	0.52	A	Lalande 45755	[illegible]	A
Piazzi VI. 305	0.82	E?	70 *Virginis*	0.64	F	ι *Piscium*	[illegible]	I
Lalande 13849	0.52	E?	*Arcturus*	2.28	K	Piazzi XXIII. 164	[illegible]	H
Procyon	1.25	F	Lalande 26289	0.55	F	85 *Pegasi*	[illegible]	I
Pollux	0.63	K?	Mayer 576	0.96	E	Piazzi XXIII. 257	[illegible]	I
28 *Camelopardalis*	0.50	I	Lalande 27744	[illegible]	H			

The notes of interrogation are taken from the Draper Catalogue; but in two instances I am doubtful of the correctness of my identification, and in both of these cases the spectrum is given as A. They are Weisse-Bessel XIII. 241, and Lalande 45755. On the other hand the Draper Catalogue contains stars with spectra of the Sirian type near the [illegible] tained is 18 of Gr[illegible] 1646 [illegible] do not seem to me [illegible]

Of 107 stars [illegible] the Sirian type to have spectra [illegible] K [illegible] of A [illegible] and 1 of the type M. [illegible] The remaining 55 are classed [illegible] E, I, G, H

and I. The spectrum B does not appear at all. The significance of this result will be evident when I mention that from a count of the stars in the Draper Catalogue I find that the Sirians (A, B, C and D) amount to more than one-half of the entire number, though they furnish less than one-tenth of Mr. PORTER's list. It will be found that the stars with spectra K and M also contribute less than their legitimate proportion.

I am disposed to infer from these and some other facts, that the sun forms one of a group or cluster of stars with spectra similar to its own. And as these stars are distinguished rather by their large proper motion than by their superior brightness, they are either of less than average mass, or of less than average luminosity. This cluster has probably a motion of its own in space, which accounts for the fact that we obtain a different apex for the sun's way when we employ stars with large proper motion from that which we obtain when we use those whose motion is less. This fact has been noticed by Mr. PORTER in a different article.

16 Earlsfort Terrace, Dublin, Ireland.

ELEMENTS OF COMET *f* 1892.

BY REV. G. M. SEARLE.

I have computed the following elements of this comet from the place previously used for Nov. 8, Prof. STONE's observation of Nov. 24, and a position which I obtained here on Dec. 10. Owing to the faintness of the comet on the last date, this position is probably not very accurate, and the first hypothesis, with computation to six places, was considered sufficient.

T = June 25.3219 Greenw. M.T.

$$\left.\begin{aligned}\omega &= 21^\circ\ 41'\ 45''\\ \Omega &= 330\ 10\ 51\\ i &= 20\ 39\ \ 0\end{aligned}\right\}\ 1892.0$$

$\log e = 9.586738$

$\log a = 0.558014$

Period 2510 days.

Middle Place O—C

$\Delta\lambda = +1''$

$\Delta\beta = -2''$

OBSERVATIONS OF COMET *f* 1892 (*HOLMES*),

MADE AT THE OBSERVATORY OF THE STATE UNIVERSITY AT COLUMBIA, MISSOURI.

BY MILTON UPDEGRAFF.

1892 Columbia M.T.		*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Nov. 9	10 8 36.1	1	5	+1 14.1	+0 17.0	0 45 14.8	+38 17 29.5	9.028	9.156
10	8 19 53.3	2	7	+1 8.0	+2 29.2	0 45 17.2	+38 11 55.2	n9.198	9.387
11	7 35 15.9	2	5	+0 11.7	—3 26.3	0 41 51.0	+38 5 59.9	n9.404	9.718
12	7 11 41.4	3	6	—2 31.6	+2 2.6	0 44 24.8	+38 0 19.6	n9.472	9.847
15	8 4 49.1	4	8	—0 21.8	+1 4.4	0 43 18.8	+37 41 29.2	n9.148	9.459
18	7 2 43.3	5	3	—2 43.5	—5 6.0	0 42 35.9	+37 22 41.9	n9.411	9.813
19	10 48 0.8	6	6	—2 47.8	+1 31.3	0 42 20.8	+37 15 35.0	9.475	9.919
21	7 45 40.0	7	4	+0 17.7	+0 42.8	0 42 8.2	+37 3 38.1	n9.099	9.559
22	7 10 38.1	7	6	+0 13.3	—5 45.1	0 42 3.8	+36 57 10.0	n9.302	9.734
25	10 29 15.9	8	6	+0 38.2	—1 29.7	0 42 1.5	+36 37 5.2	9.488	9.988

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 44 27.69	+3.02	+38 16 46.6	+25.9	W.B. O, 1092
2	0 44 6.27	+2.99 +2.98	+38 9 0.0	+26.0 +26.2	W.B. O, 1083
3	0 46 56.39	+2.99	+37 57 50.8	+26.2	Lalande 1443
4	0 43 37.63	+2.92	+37 36 58.2	+26.6	Lalande 1326
5	0 45 16.46	+2.91	+37 27 20.1	+27.8	W.B. O, 1113
6	0 39 30.15	+2.85	+37 10 36.7	+27.0	W.B. O, 979, 980
7	0 41 47.67	+2.86	+37 2 28.1	+27.2 +27.0	W.B. O, 1029
8	0 41 23.42	+2.83	+36 41 7.3	+27.6	W.B. O, 1021

As seen through our telescope of 7½ inches aperture, using a power of 150 diameters, the nucleus was faint, ill-defined and elongated in shape, rendering accurate observation difficult. On account of the extraordinary changes which took place in the aspect of the comet from Nov. 9 to Nov. 25, it is doubtful whether the same point, with reference to the center of gravity of the object, was observed on different nights. The nucleus was seen more distinctly Nov. 12 than on any other night. On Nov. 15 the observations were made through clouds and haze, while the observation of Nov. 18 is poor, having been made through clouds and mist. The comet was barely visible to the naked eye after the moon had set on Nov. 25

FILAR-MICROMETER OBSERVATIONS OF COMET *f* 1892 *[illegible]*

MADE WITH THE 12-INCH [illegible] OBSERVATORY

BY E. E. BARNARD.

1892 Mt. Hamilton M.T.	∗	No. Comp.	Δα	Δδ	α	δ	[illegible]	[illegible]
Nov. 9 11 46 55	2	10 , 4	+1 9.68	[illegible]	0 45 [illegible]	+38 16 [illegible]	[illegible]	[illegible]
10 11 51 33	2	6 , 4	+0 39.17	[illegible] 6 34.2	0 45 [illegible]	+38 [illegible] 12.7	[illegible]	[illegible]
14 7 20 34	3	5 , 4	−0 1.50	+10 10.4	0 43 36.72	+37 47 3[illegible]	[illegible]	[illegible]
16 7 41 25	3	10 , 4	−0 11.04	−2 32.8	0 43 [illegible].16	+37 34 50.9	[illegible]	[illegible]
21 7 58 4	4	*2 , 4	+0 16.71	−0 10.2	0 42 7.20	+37 2 [illegible]	[illegible]	[illegible]
Dec. 5 6 33 11	5	*2 . 4	+0 12.27	+8 6.0	0 44 17.45	+35 39 17.6	[illegible]	[illegible]
6 50 46	5	*2	+0 11.81	. . . . . .	0 44 [illegible]	. . . .	[illegible]	[illegible]
6 6 10 54	5	12 , 4	+0 36.36	+2 44.2	0 44 41.53	+35 33 54.8	[illegible]	[illegible]
7 9 6 7	5	10 , 4	+1 5.52	−3 21.1	0 45 10.68	+35 27 50.2	[illegible]	[illegible]

Mean Places for 1892.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
2	0 44 27.65	[illegible]	+38 16 46.9	[illegible]	Weisse's Bessel O. 1092
3	0 43 38.29	[illegible]	+37 36 57.0	[illegible]	Paris 1020
4	0 41 47.63	+2.86	+37 2 28.3	+27.2	Weisse's Bessel O. 1029
5	0 44 2.46	[illegible]	+35 30 43.6	+28.0	Bonn Obs., 35°151

Mt. Hamilton, 1892 *Dec.* 7.

* Δα measured direct.

EPHEMERIS OF COMET *a* 1892 *(SWIFT)*.

BY F. GERTRUDE WENTWORTH.

(Continued from p. 126.)

The equatorial coordinates reduced to 1893.0, from which the following ephemeris was computed, are

$$x = [9.9229035]\, r \sin(349°\ 4'\ 32.3'' + v)$$
$$y = [9.9997794]\, r \sin(257\ 52\ 59.1 + v)$$
$$z = [9.7384678]\, r \sin(345\ \ 5\ 28.0 + v)$$

Gr. M.T.	App. α	App. δ	log Δ	Br.
Jan. 2.5	0 10 33.7	26 49.1	0.5680	[illegible]
4.5	12 10.6	39.5		
6.5	13 49.0	30.5	0.5796	[illegible]
8.5	0 15 28.6	26 22.3		
Jan. 10.5	0 17 9.0	26 11.6	[illegible]	[illegible]
12.5	18 51.8	7.6		
14.5	20 35.7	26 1.1	[illegible]	[illegible]
16.5	22 20.4	25 55.2		
18.5	24 6.7	49.9	[illegible]	[illegible]
20.5	25 54.1	45.1		
22.5	27 42.4	40.8	[illegible]	
24.5	29 [illegible]	[illegible]		
26.5	31 2[illegible]	[illegible]3.7	[illegible]	
28.5	[illegible]	[illegible]		
30.5	0 35 [illegible]	25 28.6	[illegible]	

OBSERVATIONS OF COMET *f* 1892 *(HOLMES)*.

Prof. ORMOND STONE, of the University of V[illegible] McCormick equatorial, employing W.B. O. 1021 as comparison-star:

1892 Greenwich M.T.	No. Comp.	Δα	Δδ	α	δ
Nov. 21 15 49 43	21 , 5	[illegible] 8.87	[illegible]	[illegible]	[illegible]

Miss WHITNEY, Professor at Vassar College, sends [illegible]

1892 Poughkeepsie M.T.	[illegible]	[illegible]	Δ
Dec. 9 10 56 6	0 46 7.1	[illegible]	[illegible]

ELEMENTS AND EPHEMERIS OF COMET *f* 1892.

BY LEWIS BOSS.

The elements of Comet *f* presented herewith are founded [illegible] on a position of the comet for Nov. 8, derived from the determinations at Mt. Hamilton and Cambridge of that date [illegible] a place for Nov. 21 formed from the Princeton observation[illegible] as follows:

Elements for 1892.0.

Epoch, 1892 Nov. 21.5, Gr. M.T.

$$
\begin{aligned}
M &= 27^\circ\ 16'\ 18''.58\\
\omega &= 13\ \ 19\ \ 19.6\\
\Omega &= 331\ \ 15\ \ 35.9\\
i &= 20\ \ 18\ \ \ 0.0\\
\varphi &= 21\ \ 17\ \ 50.3\\
\mu &= 513''.1702\\
T &= 1892\ \text{June}\ 12.6162\\
\log q &= 0.3295977\\
\log a &= 0.5598301
\end{aligned}
$$

Equations for Heliocentric Coordinates.

Equator of 1892.0

$$
\begin{aligned}
x &= r[9.9937812]\ \sin(v + \ \ 77^\circ\ 10'\ 10''.8)\\
y &= r[9.8762726]\ \sin(v + 338\ \ 34\ \ 16.9)\\
z &= r[9.8325961]\ \sin(v + 357\ \ 15\ \ 21.7)
\end{aligned}
$$

Equator of 1893.0

$$
\begin{aligned}
x &= r[9.9937869]\ \sin(v + \ \ 77\ \ 10'\ 59''.1)\\
y &= r[9.8762535]\ \sin(v + 338\ \ 35\ \ 16.6)\\
z &= r[9.8326073]\ \sin(v + 357\ \ 45\ \ 50.2)
\end{aligned}
$$

The comparisons with observations subsequently exhibited indicates that the foregoing elements are likely to prove substantially near the truth. With these, the comet of HOLMES may approach the orbit of *Jupiter* within the distance of 0.37 at longitude 151°; and during nearly a year the distance of the comet from that orbit is less than 0.7. The periodic time of 6ʸ.914 (2525.5 days) shows, however, that no very close approach to *Jupiter* can have taken place in recent years. The eccentricity is, however, so small that very important perturbations by *Jupiter* may have occurred when the comet was comparatively distant from its aphelion. With the present elements undisturbed no very close approach to *Jupiter* is likely to have occurred during the past fifty years.

The recent remarkable decrease in brightness of the comet seems to do away with the necessity of supposing that it has been recently made a member of the solar system. This decrease also renders it reasonably certain that the comet must have been subjected to some extraordinary disturbance of its internal economy, by the application of forces from without or within, with the result of giving to it that which was really an unaccustomed and temporary size and brightness.

Observers generally — and especially those who possess only moderate optical appliances — doubtless have experienced some difficulty in obtaining satisfactory measurements for position upon this comet. A comparison of the foregoing elements with published observations may therefore possess some interest. In making the comparisons somewhat rigorously, I have rarely attempted any revision of the observations, for the improvement of defective star-positions, though I have occasionally substituted modern star-positions for those of LALANDE or BESSEL where this could be done with entire convenience, and where such substitution appeared to improve the result. In the following tables, after the names of the respective observatories and observers, the approximate Greenwich date of each observation, corrected for aberration, is given, and this is followed by the difference from the ephemeris place in the sense, Observed — Computed.

Vienna — WEISSE (W), PALISA (P), HOLETSCHEK (H), BIDSCHOF (B).

		h	m	s	″	
Nov.	8	10	19	+0.27	+ 0.4	B.
		10	53	+0.28	− 1.0	W.
	9	5	25	+0.69	− 6.3	H.
		6	20	−0.15	+ 2.2	B.
	13	6	31	+3.23	− 8.5	H.
		7	58	+1.50	+ 15.8	B.
	17	4	54	+0.07	+ 1.1	P.
		5	0	+1.72	− 16.0	H.
		5	26	+0.51	+ 0.6	B.
		5	50	+0.33	+ 1.6	W.

Cambridge (Mass.) — WENDELL.

		h	m	s	″
Nov.	8	13	52	−0.37	+ 0.2
		18	30	−0.67	+ 2.4
	10	17	47	+0.56	+ 3.3
	11	13	39	−0.61	− 2.0
	14	12	22	−1.78	− 6.0
	16	19	21	−0.66	− 0.5
	17	12	31	−1.59	+ 1.3
	19	15	15	−0.06	−173.1
	20	18	27	−0.02	− 61.8
	22	12	42	−1.36	+ 1.9
	23	12	28	−1.05	+ 7.1
		15	13	−0.96	+ 4.4

Mount Hamilton — BARNARD.

		h	m	s	″
Nov.	8	16	21	+0.44	− 3.2
	9	19	41	+1.08	+ 2.6
	10	19	48	+0.34	− 29.1
	14	15	14	+0.02	+ 1.1
	16	15	38	+0.12	− 4.3
	21	15	51	−0.16	+ 1.5

Leipsic — HAYN.

		h	m	s	″
Nov.	9	6	41	−0.75	− 12.1

Paris — BIGOURDAN.

		h	m	s	″	
Nov.	9	8	44	+0.29	− 2.9	(2 series)
	13	10	56	+0.74	−118.6	(5 series)

For November 13, there appears to be an error of 2′ in declination.

Carlsruhe — RISTENPART.

		h	m	s	″	
Nov.	9	10	50	+1.27	− 9.4	(2 series)

Washington (Cath. Univ.) — SEARLE.

		h	m	s	″	
Nov.	10	20	57	+0.53	− 8.9	(2 series)
	11	14	10	+0.63	+ 21.1	(2 series)
	13	13	20	+0.20	+ 0.9	
	16	13	40	+0.08	+ 30.3	
		14	55	+1.98	+ 20.0	
	18	13	23	+1.62	− 5.2	
	21	13	38	−0.67	+ 16.5	

Boston University — COIT.

		h	m	s	″
Nov.	11	13	2	+2.31	+17.7

Poughkeepsie — Miss WHITNEY.

		h	m	s	″
Nov.	11	15	55	−0.62	− 6.6
	16	15	47	−0.34	− 0.8
	18	15	42	+1.89	− 2.0
	19	12	15	+0.53	+ 8.7
	20	11	43	+0.59	− 6.0
Dec.	9	15	16	+2.25	−10.7

New York (Columbia Coll.) — REES (R), JACOBY (J).

		h	m	s	″	
Nov.	11	16	13	−1.45	− 4.3	R.
		16	48	+0.12	+14.1	R.
	16	15	6	+0.36	+ 5.1	R.
	20	10	17	+1.57	−52.6	R.
		11	0	+0.28	−49.8	J.
	21	15	8	+0.33	−27.5	R.

Northfield — WILSON.

		h	m	s	″
Nov.	11	17	0	−0.16	− 0.4
	15	15	4	−0.30	+ 0.6
	18	15	43	+0.33	+ 1.5
	22	15	33	−0.03	+ 0.7

Bordeaux — Rayet (R), Picart (P).

	h m	s	″	
Nov. 12	10 8	+0.71	—18.4	R.
13	5 12	+0.27	+ 0.4	R.
15	5 50	—0.05	— 0.2	P.

Prague — Gruss.

Nov. 13	5 22	+1.09	— 4.8

Berlin — Knorre.

Nov. 13	5 48	+0.36	— 7.3
	11 47	+0.21	— 1.3
14	5 28	+0.19	+ 0.5
15	4 50	+0.45	— 1.8

Göttingen — Schur.

Nov. 13	6 4	+0.19	— 2.0
	13 14	+1.30	+ 4.1
16	5 7	+6.61	— 9.4
19	5 15	+1.32	— 5.3

Hamburg — Schorr.

Nov. 13	6 4	+0.19	— 2.0
13	13 14	+1.30	+ 4.1
16	8 43	+0.84	+ 2.4
	11 48	+0.57	— 5.4
17	5 51	+0.43	+ 0.9
18	7 14	+0.63	+ 2.2

Kiel — Lamp.

Nov. 13	6 57	+0.73	+ 1.1
	12 44	+0.20	— 0.6
14	15 3	+0.92	— 3.8
17	11 1	+0.64	— 1.5
18	6 9	+1.30	+ 4.2

Bothkamp — Moller.

Nov. 13	7 56	+0.23	—19.0
17	5 24	+0.07	—13.9

Albany — Boss (B), Lay (L).

Nov. 13	12 2	—0.35	— 0.8	B.
17	12 38	—0.06	+ 2.7	B.
18	17 10	+0.60	— 2.0	L.
20	11 15	+0.06	+ 2.5	L.
22	12 6	—0.11	— 9.3	B.
Dec. 9	14 22	+0.01	— 0.2	B.
	16 7	+0.97	+ 3.8	L.
15	14 54	—0.38	—13.1	L.

Lyons — Cadet.

Nov. 15	8 25	+0.21	+ 1.5
	10 15	—0.10	+15.4

Königsberg — Cohn.

Nov. 21	5 36	—0.03	— 8.0

Princeton — Reed.

Nov. 21	15 38	+0.05	+ 1.9

University of Virginia — Stone.

Nov. 21	15 36	+0.52	+ 1.9

Columbia (Mo.) — Updegraff.

Nov. 9	16 15	+ 0.3	— 1.7
10	14 16	+ 0.5	1.8
11	13 32	+ 1.3	— 14.7
12	15 8	+ 1.1	— [illegible]
15	14 1	+ 0.3	+ 0.6
18	12 59	+ 2.1	— 13.2
19	16 44	— 0.4	+ 0.9
21	13 41	+ 0.6	+ 1.1
22	13 6	+ 0.2	—15.0
25	16 25	+ 0.5	— 25.4

The observer describes the observation of Nov. 18 as poor.

Rome — Millosevich.

Nov. 10	4 42	+0.76	— 5.4
11	4 51	+0.86	— 1.0
12	8 4	+0.27	+ 2.3

Padua — Abetti.

Nov. 10	8 29	+1.09	—11.3
11	6 47	+1.37	— [illegible]
14	7 8	+1.24	— 25.0

I have formed corrections to the ephemeris by a somewhat summary process and obtain the following at the dates indicated:

	Δα	Δδ
	s	″
Nov. 9.8	+0.25	—1.6
13.9	+0.29	—1.3
18.0	+0.23	+0.7
22.6	0.00	—0.7
Dec. 11.6	+0.20	—3.5

One fairly obvious conclusion from the comparisons seems to be that, with smaller telescopes, the right-ascensions obtained are usually greater than the mean. The small number of observations in most cases, and the need of revision of the star-positions in many, would render an evaluation of systematic corrections useless at present. Yet in some cases they already appear rather well marked. Thus, the right-ascensions obtained at Hamburg appear to require a correction of about —0ˢ.10, those at Kiel a correction of about —0ˢ.50, and those at the Harvard College observatory a correction of +0ˢ.96, in order to reduce them to the general mean.

I cannot refrain from calling attention to the renewed and striking demonstration of the inutility of the ring-micrometer, which the observations of this comet afford.

The following ephemeris was computed by my assistants, Mr. William O. Lay and Mr. Charles S. Benton, and is intended to be sufficiently rigorous to admit of accurate comparisons with observations. It is scarcely necessary to remind the possessors of large telescopes of the importance of observations upon this very interesting comet so long as it shall remain visible.

Ephemeris for Greenwich Midnight.

	App. α	App. δ	log Δ
	h m s	° ′ ″	
1892 Dec. 20.5	0 53 9.67	+34 30 26.9	[illegible]
22.5	54 47.18	34 23 23.1	[illegible]
24.5	56 30.84	34 16 51.8	[illegible]
26.5	0 58 19.57	34 10 [illegible]	[illegible]
28.5	1 0 13.13	34 5 27.6	[illegible]
30.5	2 12.21	34 0 31.3	[illegible]
1893 Jan. 1.5	4 15.71	33 56 12.9	[illegible]
3.5	6 23.72	33 [illegible] 22.7	[illegible]
5.5	8 36.07	33 49 [illegible]	[illegible]
7.5	10 52.57	33 46 [illegible]	[illegible]
9.5	13 13.10	33 43 [illegible]	[illegible]
11.5	15 37.51	33 [illegible] 1.3	[illegible]
13.5	18 5.68	33 40 [illegible]	[illegible]
15.5	20 37.47	[illegible]	[illegible]
17.5	23 12.73	[illegible]	[illegible]
19.5	25 54.31	[illegible]	[illegible]
21.5	28 33.08	[illegible]	[illegible]
23.5	31 17.92	[illegible]	[illegible]
25.5	34 5.70	[illegible]	[illegible]
27.5	36 56.28	[illegible]	[illegible]
29.5	39 49.5[illegible]	[illegible]	[illegible]
31.5	42 45.58	[illegible]	[illegible]
Feb. 2.5	1 45 13.6[illegible]	+3[illegible]	[illegible]

RING-MICROMETER OBSERVATIONS OF COMET *f* 1892 (*HOLMES*),

MADE AT COLUMBIA COLLEGE OBSERVATORY, N.Y. CITY, WITH RUTHERFURD EQUATORIAL (13-INCH APERTURE),

BY J. K. REES.

1892 Col. Coll. M. T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log *p*Δ for α	log *p*Δ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Nov. 11 11 39 38.1	1	1 , 1	—2 14.9	+7 24.4	0 11 11.56	38 5 33.9	9.519	*n*9.751
12 5 27.9	2	2 , 2	+0 36.2	—3 43.2	0 11 45.12	38 5 43.1	9.580	*n*0.020
21 10 25 51.8	3	3 , 3	+0 17.1	—0 7.3	0 42 7.60	37 2 18.2	9.407	8.650

Mean Places of Comparison-Stars for 1892.0.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 16 56.46	+3.00	+37 57 13.1	+26.13	Paris 1102 = Lalande 1143
2	0 41 6.21	+2.98	+38 9 0.4	+26.21	Weisse's Bessel O. 1083
3	0 41 17.63	+2.87	+37 2 28.3	+27.19	Weisse's Bessel O. 1029

REMARKS.

Nov. 11. Coma about 8′ in diameter. Nucleus appears to be spread out toward northwest. Northern side of coma more sharply defined than southern side. Northern end of elongated nucleus slightly brighter than other parts. There were indications of divisions in the nucleus. Nov. 21. Coma about 15′ in diameter. Nucleus indistinct and diffuse. Comet faint.

EPHEMERIS OF COMET *d* 1892 (*BROOKS, Aug. 28*),

BY GEORGE A. HILL.

[Continued from No. 279.]

G M.T.	α	δ	log Δ	Br.	G M.T.	α	δ	log Δ	Br.
1892.	h m s	° ′			1893	h m s	° ′		
Dec. 26	13 19 17	—36 10.2	9.9920	28.4	Jan. 13	15 25 44	—41 38.4		
28	14 0 57	37 6.9			15	35 27	41 53.2	0.0589	18.9
30	12 3	37 58.1	0.0055	26.7	17	44 54	42 4.7		
Jan. 1	23 5	38 43.9			19	15 54 6	42 13.1	0.0711	17.1
3	33 50	39 24.5	0.0191	24.8	21	16 3 2	42 18.8		
5	44 13	40 0.2			23	11 42	42 21.8	0.0825	15.4
7	14 55 16	40 31.1	0.0328	22.8	25	20 5	42 22.4		
9	15 5 37	40 57.6			27	16 28 12	—42 20.3	0.0931	14.9
11	15 15 48	—41 19.9	0.0461	20.8					

NEW ASTEROIDS.

Prof. KREUTZ sends notice of four asteroids, photographed by CHARLOIS at Nice, on Nov. 23, 24, 25, and 28, and observed by him on subsequent dates.

O. Nov. 24. 8h 16m.1 Nice M.T. $\alpha = 41° 55' 49''$. $\delta = +10° 12' 10''$.
Daily motion, —10′ in α, and 7′ southward. 11M.

P. Nov. 27. 7h 36m.9 Nice M.T. $\alpha = 54° 26' 58''$. $\delta = +11° 27' 53''$.
Daily motion, —12′ in α, and 1′ northward. 11M.

Q. Nov. 29. 8h 8m.2 Nice M.T. $\alpha = 57° 43' 31''$. $\delta = +12° 23' 37''$.
Daily motion, —15′ in α, and 0 in δ. 12M.

R. Nov. 29. 8h 32m.4 Nice M.T. $\alpha = 59° 52' 41''$. $\delta = +13° 29' 10''$.
Daily motion, —13′ in α, and 2′ northward. 12½M.

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ON THE INFLUENCE OF LATITUDE-VARIATIONS UPON ASTRONOMICAL CONSTANTS AND MEASUREMENTS.

By S. C. CHANDLER.

Since the publication of the law of the rotation of the earth's pole, in the series of papers ending with no. 277 of this Journal, there have appeared two interesting confirmations of it; first, the communication by Prof. ALBRECHT, (*A.N.* 3131), of the results at Honolulu and the simultaneous observations at European observatories, all by TALCOTT's method; secondly, *Bulletin* 25, *U.S. Coast and Geodetic Survey*, giving Mr. EDWIN SMITH's observations, also by TALCOTT's method, in 1891–92, at Rockville, Md. To show how precisely the formula (15), p. 100, conforms to all these results, I give below the dates of the several maxima and minima computed* for the Berlin meridian, and their comparison with the observed dates at the various places, after applying the proper reductions for the difference in the times of the phases at the other stations, by virtue of the rotation of the pole from west to east. These reductions, additive to the Berlin dates, are: Prague, +1d; Strassburg, —7d; Pulkowa, +1[illegible]; Rockville, —37[illegible]; Waikiki, —200[illegible].

		Comput. eq. 15	O — C							
		Berlin meridian	Berlin	Prague	Strassb.	Pulkowa	Rockville	Honolulu	Mean	[illegible]
			d	d	d	d	d	d	d	
A	Max.	1889 Aug. 19	+18	—19	–	–	–	–	— 0.5	2
B	Min.	1890 Feb. 28	—12	—13	–	–	–	–	—12.5	2
C	Max.	1890 Sept. 9	— 7	0	–	—14	–	–	— 7.[illegible]	3
D	Min.	1891 Mar. 22	— 6	—24	–	— 5	–	–	— 8.3	[illegible]
E	Max.	1891 Oct. 3	— 2	+ 2	+15	—18	—15	–	— [illegible]	[illegible]
F	Min.	1892 Apr. 11	(+17)	(+31)	+13	(+23)	–	+ 4	+ 8.[illegible]	[illegible]
G	Max.	1892 Oct. 21	–	–	–	–	–	+ 8	+ 8	[illegible]

The values in parentheses are extremely uncertain, being roughly estimated from incomplete determinations of the phase. The mean of the values of O—C gives a correction to the formula of only —5d.3; and the accordance of the separate values is high testimony to the skill of the observers, to whom astronomers owe a deep debt of gratitude for their laborious and conscientious work.

As additional confirmation of the law, I give below, by the side of the periods deduced by Prof. ALBRECHT from the observations directly, the mean observed values, and in the last column the theoretical periods according to eq. (15). It will be seen that the observations and the formula agree precisely in fixing the present length of the period at 387d.

		Berlin	Prague	Pulkowa	Mean	[illegible]
C	A	[illegible]	[illegible]	–	[illegible]	[illegible]
D	B	[illegible]	376	–	[illegible]	[illegible]
E	C	[illegible]	[illegible]	[illegible]		[illegible]
Mean		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

F[illegible] above [illegible] to the observations of [illegible] charts [illegible] no. 277 [illegible] law of [illegible] rotation, as established in this series [illegible] question the correct one.

---

* Using the value of $r_2 = 0''.16$, its mean amount for the interval 1889–92, from eq. 17.

Some very important questions now arise. The relations of the variations of latitude to the higher practical astronomy are vital. Heretofore all determinations of the celestial coordinates, and of the various astronomical constants, have been made on the assumption of an invariable zenith. It will be easy to avoid this assumption, by appropriate changes in methods, in future determinations, but to rectify its consequences in the past is a problem which now confronts astronomy, and will be difficult and laborious. A little consideration will show that these consequences reach further than might at first sight be supposed, and that nearly everything that concerns absolute astronomical measurement must have been to a greater or less extent vitiated — equator-point, equinoctial point, obliquity of the ecliptic, aberration-coefficient, absolute measurements of parallax, absolute systems of right-ascensions and declinations, and even, possibly by sensible amounts, the refraction, nutation, and precession constants.

To examine the subject generally, let us write equation (11), p. 99, for the correction of the periodical variation of latitude, in the general form * (19)

$$\Delta\varphi = \varphi_0 - \varphi = r_1 \cos[\lambda + (t - T_1)\theta] + r_2 \cos(\lambda + \odot - G)$$

where λ is the longitude of the place of observation, and the motion of rotation, in both terms, is taken from west to east. This is not a mere assumption, but has been concluded from direct investigation, although I have not yet given the proof explicitly in these articles; nor can I stop here to do so, except merely to say that, as regards the first, or 427-day term, the evidence of the observations is conclusively unanimous on this point, independently of the theoretical considerations which require it; and that, as to the annual term, the testimony is nearly as satisfactory. But, in any event, the following inferences will not be invalidated.

First, what will be the effect on determinations of the equinoctial point? For the sun we have, since $\beta = 0$,

(20) $\tan\varepsilon \sin\alpha = \tan\delta \quad , \quad \cos\varepsilon \tan\odot = \tan\alpha$

whence, since $d\delta = d\varphi$,

(21) $d\alpha = \cot\varepsilon \sec\alpha \sec^2\delta \, d\varphi = 2\cos\varepsilon \operatorname{cosec} 2\delta \tan\odot \, d\varphi$

Now $\Delta\varphi$ in eq. (19), taken as a whole, has generally nearly the same numerical values, but opposite signs, at the two equinoxes of any year, and may amount to $0''.30$ with the values of the coefficients prevailing during the last half century. But its coefficient in eq. (21) also has opposite signs at the two equinoxes, and is about equal to $\cot\varepsilon$, or 2.3. The correction of the equinoctial point, determined from two observations of the sun at corresponding vernal and autumnal declinations, may therefore amount to nearly $0^s.05$; and the same is true of the result from a combination of all the observations at those equinoxes. Let us, however, analyse the effect of the two terms of (19) separately. It is readily seen that the correction due to the first, or 427-day term, is partially eliminated by combining several years, and completely, if seven years observations are employed. With the second, or annual term, the case is far different. For this alone equation (19) gives, at the equinoxes, $\Delta\varphi = \pm r_2 \cos(\lambda - G)$, consequently a minimum value of

$$\Delta\alpha = + r_2 \cot\varepsilon \cos(\lambda - G)$$

which becomes

$+2.3\, r_2 \cos G$ for $\lambda = 0$; $\pm 2.3\, r_2 \sin G$ for $\lambda = \pm 90°$.

From eq. (15), p. 100, $G = 350°$. My more recent determinations give a somewhat smaller value, but not enough so to affect the correctness of the following inferences from the above relations.

The present value of r_2 is nearly $0''.20$, which was its value also after 1840; for intermediate dates it was apparently much smaller; while at the time of BRINKLEY and BRADLEY it was apparently much larger, say $0''.40$ or $0''.50$. Consequently it is certain that most previous European determinations of the equinoctial point require a positive correction of a few hundredths of a second of time, the amount of which depends on the coefficient of the annual term of the latitude-variation, which we do not yet fully know. Taken in connection with the uneliminated errors due to the 427-day term, this correction may amount to as much as $+0^s.06$ in some cases. On the contrary, determinations in the United States would be nearly free from error of the sort.

I am convinced that we have here a sufficient and real interpretation of the hitherto unexplained discordances among the various determinations of this important zero-point of right-ascensions. In particular cases the discordances are about what we should expect, both in amount and sign, if such is indeed their origin. Thus in the Pulkowa (1865) equinox, based on nine years' solar observations, the effect of the 427-day term is probably nearly eliminated, while the small value of r_2, $0''.05$ (see p. 100), then prevailing, would give a correction of but $+0^s.008$. Its close accordance with NEWCOMB's value from the Washington observations, Pulkowa (1865) — Washington $= -0^s.002$, is therefore natural. On the other hand, we have, Pulkowa (1865) — Pulkowa (1845) $= +0^s.055$, which may be accounted for by the larger value of r_2 about 1845. Probably the large difference Pulkowa (1865) — Greenwich $= +0^s.066$ might largely disappear, on investigation, for the same reason.

As regards the obliquity, similar considerations show that $\Delta\varepsilon = -r_2 \sin(\lambda - G)$, which becomes, nearly,

$+r_2 \sin G$ for $\lambda = 0°$; $\mp r_2 \cos G$ for $\lambda = \pm 90°$

so that the obliquity is very nearly right from European observations, but would be too large, by r_2 (nearly), if found from observation in the United States.

---

* To avoid confusion and repetition, the numbering of formulas in this and the following articles containing the rediscussions of the aberration-constant, will be continued from the previous articles on the latitudes.

Another conclusion of extreme importance to practical astronomy is that the annual term in the variation of the zenith implies the necessary existence, in all catalogues of declinations, of a systematic error depending on the right-ascension, except in northern stars where it has been eliminated by observations at both culminations. Such an error can only be detected and eliminated by comparison of catalogues constructed in widely different longitudes. It appears probable that the terms of this sort that appear in Boss's systematic corrections for the Washington observations, and other like cases, may be traced to this source.

One of the most singular episodes in modern astronomy is the retrogression of ideas with regard to the accuracy of our knowledge of the constant of annual aberration. Astronomers a quarter of a century back, having accepted implicitly the result of Struve's classical research, shared his expressed conviction that no other element in astronomy was known with equal precision. Indeed, many were inclined to believe further research useless. Even now those who have not intimately examined the subject are either resting in the same sense of fancied security, or are unaware that it is no longer the third or the second decimal place which is in question, but that the uncertainty extends even to the first, and that in fact this constant is now to be regarded as an unknown quantity. The result of each successive investigation of it appears to widen the possible range within which its real value may ultimately be found, so that we are now called upon to reconcile discrepancies like that comprised between Kustner's value of 20".31 and Nyren's of 20".54, for example. The attempts to devise methods which are independent of the systematic errors of the older ones are not very reassuring. Thus, Loewy's promising and beautiful method gives, in different hands, 20".447 and 20".491. It was not unnaturally to be expected that the rediscussion of the existing determinations, eliminating the effect of the variations in the position of the zenith, might bring them into accord. With this idea I have been engaged for several months upon this rediscussion, including some data not heretofore utilized for the purpose. This labor is now approaching completion, and is in fact partly ready for publication; and will shortly appear in a series of papers in this Journal, "On the Constant of Aberration." The results present some curious features. While the anomalous parallaxes which have been conspicuous in some cases, are satisfactorily disposed of, — the internal accordance in the separate observations strikingly improved, — and marked changes made in the values formerly deduced, — it must be regretfully recognized that the upshot of the whole investigation leaves much to be desired, in point of harmony, among the reconstructed values of the aberration-constant. But further comment is reserved until the various discussions have been presented.

ON A NEW VARIABLE IN *CYGNUS*.

($\alpha = 21^h\ 37^m\ 17^s.9$, $\delta = +37°\ 21'.2$, 1855.)

BY PAUL S. YENDELL.

My observations, from 1891 July 9 to 1892 Dec. 9, show this star to be variable to the extent of about two magnitudes, in a period which is probably long or irregular.

The star is DM. 37°4107; $7^{\rm M}.8$; = Birmingham 592; $7^{\rm M}.8$; = Bessel XXI. 923; $8^{\rm M}.0$; = Yarnall 9765; $6^{\rm M}.0$.

Its light is intensely red, to my eye, approaching the color of a railway lantern; Mr. Gore, in a private letter, alludes to it as "one of the reddest stars in the sky;" a few comparisons made after the method described by Chandler in Vol. VIII of this Journal, p. 137, indicate that it is in the neighborhood of 9.0 of his scale of redness.

When first observed by me, 1891 July 9, the star was found = DM. 37°4101, or $7^{\rm M}.5$; a minimum followed about Oct. 8, the star being estimated as = DM. 37°4100, or $9^{\rm M}.3$; and when last observed for the season, 1892 Jan. 7, it had risen to $7^{\rm M}.8$. Observations on it were resumed 1892 May 16, and a maximum of $7^{\rm M}.1$ was observed about August 8; when last observed, Dec. 9, it was $9^{\rm M}.0$.

As indicated by my observations, the character of the variation is peculiar; intervals of stationary or slowly changing light alternating with abrupt accessions or losses, to the extent, at times, of a full half-magnitude; at both the maximum and minimum observed by me, the light-curve was very flat.

Assembling Espin's quotations (*Es. B*[illegible]) and such observations as I have been able to find, including Yarnall's original observations, kindly furnished me by Prof. Frisby, we have the following estimates of magnitude.

			M	
1847	Sept.	3.	9.0	Yarnall.
	Sept.	4.	9.0	"
1848	Oct.	6.	9.10	"
	Oct.	9.	9.0	"
1856	Sept.	5.	8.0	Lassell, "deep red."
1868	Aug.	31.	6.0	Yarnall.
	Sept.	18.	6.0	"
1870	Oct.	10.	6.8	Radcliffe Observatory.
1871	Aug.	11.	7.5	" "
1874	May	8.	7.5	Birmingham, "fine red."
	June	15.	7.8	" "splendid red."
1875	May	15.	8.0	" " "
	July	27.	8.0	" " "
	Sept.	10.	8.0	Dunsink Observatory, "[illegible]"
	Sept.	28.	7.3	" " "very [illegible]"
	Nov.	26.	8.0	Birmingham, "[illegible]"
1876	May	19.	8.0 at least	" "[illegible]"
1878	Sept.	18.	7.0	Dunsink Observatory, "very [illegible]"
	Sept.	25.	7.5	" " "very [illegible]"

Argelander, BB. VI. p. 202, $7^{\rm M}.0$, [illegible]; $7^{\rm M}$. [illegible]

The above observations furnish but meagre data upon

which to found an estimate of period. It seems certain, however, from my own observations, that it must be more than a year; and taking the indications of these, with what can be inferred from the above table, an estimate of 170± days seems a not impossible value; this is also accordant with what may be inferred from the star's extreme redness, in consideration of the relation between color and period, the existence of which seems to be demonstrated by Chandler, in Vol. IX, p. 2, of this Journal.

The comparison-stars used, with the light-scale and magnitudes deduced from my observations, are as follows:

		DM.	Y.	Light
e =	DM. 37°1110	$7^{\mathrm{M}}.2$	$7^{\mathrm{M}}.0$	23.3
a =	37°1104	8.0	7.5	18.0
k =	36°1679	7.7	7.8	14.8
b =	37°1105	8.2	8.2	10.8
d =	37°1118	8.5	8.6	7.1
f =	37°1101	8.8	8.7	6.0
c =	37°1100	9.3	9.3	0.0

It is very desirable that the variability of this star should be confirmed by other observers, and that its period may be determined by actual observation.

Dorchester, Mass., 1892 *Dec.* 10.

ANCIENT CHRONOLOGY AND ECLIPSES—A REPLY.

By W. T. LYNN, B.A., F.R.A.S.

1. I do not feel it incumbent upon me to take up much space in replying to Mr. Stockwell's remarks in No. 280 upon my criticisms in No. 251 of his earlier paper. I am glad that he has "disposed of" my objections to his own satisfaction, though I scarcely think that he has refuted them, or shown my inferences to be erroneous.

2. It was unfortunate that Mr. Stockwell took the date of the death of Darius from the modern compilation of Rollin, instead of referring to the ancient authorities. But when I had pointed out the mistake, it was surely an odd way of writing to say that he has found the true date was in the Olympic year following the one he had supposed. It was only in reference to this that I stated that, according to his own statement (from Rollin) of date, the conclusion would be the opposite to that which he had drawn respecting the year of the battle of Arbela. Too much has probably already been said about Calpurnia's night-mare. I certainly never maintained, nor did Plutarch say, that her slumbers were disturbed by the light of the moon. What he says (and it must be remembered he was not a contemporary) is that she was disturbed by the doors and windows flying open, and Caesar saw her by the light of the moon, which he might well do if the large waning crescent were rising and shining into the room. I should think more of Mr. Stockwell's argument in regard to the Spanish War, had the account been written by Caesar himself, or by some one equalling him in perspicuity, in which the actual writer much fails.

3. But I do not wish to go over ground again which I have already sufficiently traversed. It appears to me that the Roman history of the first century has been too carefully mapped out to admit of the alterations of date suggested by Mr. Stockwell. My principal concern now is with the "perfectly satisfactory and triumphant confirmation" which he derives for his views from the so-called eclipse of Phlegon. Now, as Mr. Jarvis points out, there is uncertainty as to the Olympic year mentioned by Phlegon, of whose writings fragments only are extant. Mr. Stockwell says "the earliest date given is by John Philoponus," and this is certainly true, but an incautious reader might think he meant the earliest authority. Not only do most of the authorities give the fourth, not the second (one gives the third) year of the 202d Olympiad, but Philoponus himself gives in another place in the same chapter (*De Mundi Creatione*, lib. ii, c. 21) the fourth year. [This is quoted by Lardner, who oddly enough says that the former passage makes it the 102d Olympiad, though he quotes the Greek correctly as the 202d in a note.] There can be little doubt, therefore, as Mr. Jarvis says, that the fourth year of the 202d Olympiad "is most probably the true reading." This would correspond to A.D. 32, or, according to Mr. Stockwell, A.D. 31, in neither of which years was there a total eclipse of the sun.

4. I shall not touch here upon the latter part of Mr. Stockwell's paper, as I am only concerned with eclipses. His calculation of the conjunction of *Jupiter* and *Venus* in B.C. 6 is interesting; but I must say I cannot see how such a phenomenon could constitute the "star of the Magi," which moved before them, and ultimately appeared to stand over a house. Nor can I reconcile Christ's birth in B.C. 6, and death in A.D. 33, with Luke iii. 23. I believe the Crucifixion took place on April 7, in A.D. 30, and the Paschal full moon the day before, *i.e.* Thursday. But these questions cannot well be discussed in detail in the columns of the *Astronomical Journal*, and I must apologize for taking up too much space already.

Blackheath, S.E. England, 1892 *Dec.* 2.

OBSERVATIONS OF COMETS,

MADE AT THE HARVARD COLLEGE OBSERVATORY,

BY O. C. WENDELL, ASSISTANT.

(Communicated by Professor E. C. Pickering, Director.)

1892 Cambridge M.T.	*	No. Comp.	☌' — * Δα	☌' — * Δδ	☌'s app. place α	☌'s app. place δ	[illegible] Δ	
			Comet a 1892.					
May 18 13 59 10	1	5	+1 28.30	+ 5 9.6	23 22 0.77	+3[illegible]	[illegible]	[illegible]
24 14 4 17	2	5	+2 30.91	+ 3 18.6	23 36 58.27	+31 24 48.[illegible]	[illegible]	[illegible]
June 15 12 21 10	3	5	—1 58.59	+ 0 17.[illegible]	0 22 43.2[illegible]	+42 [illegible] 2[illegible]	[illegible]	[illegible]
July 20 10 52 46	4	5	—2 8.52	— 3 33.1	1 2 1.07	+50 22 [illegible]	[illegible]	[illegible]
23 11 18 51	5	5	—3 19.21	—12 8.2	1 3 9.71	+50 49 [illegible]	[illegible]	
Sept. 2 10 31 46	6	5	—1 18.12	— 0 23.1	0 39 56.38	+52 32 31.[illegible]	[illegible]	
27 8 15 8	7	5	+0 57.81	— 9 15.0	0 8 2.11	+48 21 [illegible]	[illegible]	[illegible]
			Comet d 1892.					
Sept. 1 13 5 12	8	5	—0 32.39	+ 0 37.1	6 9 1.66	+31 [illegible] 51.2	[illegible]	[illegible]
2 14 58 13	9	5	—0 20.64	+ 5 13.6	6 11 42.48	+31 29 [illegible]	[illegible]	[illegible]
			Comet e 1892.					
Oct. 19 8 26 20	10	7	+1 8.24	+ 9 13.5	19 46 59.81	+10 18 23.7	[illegible]	[illegible]
			Comet f 1892.					
Dec. 7 8 22 50	11	1	+0 59.65	— 2 12.5	0 45 4.81	+35 28 57.7	[illegible]	[illegible]
9 8 31 12	12	9	+0 33.61	+ 2 23.1	0 16 0.57	+35 18 22.[illegible]	[illegible]	[illegible]

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	23 20 32.89	—0.42	+31 26 5.4	—12.1	Weisse's Bessel XXIII. [illegible]
2	23 34 27.72	—0.36	+31 21 32.3	— 2.0	" " " 707
3	0 24 41.82	0.00	+42 32 24.9	9.1	B.B. VI. 12 [illegible]
4	1 4 11.18	+1.11	+50 26 13.9	5.0	O. A. [illegible] 1166.7
5	1 6 27.68	+1.24	+51 1 53.4	5.7	" " 1221.2
6	0 41 11.76	+2.74	+52 32 46.9	+ 7.6	" " 7[illegible]1
7	0 7 1.40	+2.93	+48 31 3.9	+17.1	" " [illegible]
8	6 9 34.36	—0.31	+31 35 9.1	+ 1.1	Weisse's Bessel VI. 178.[illegible]
9	6 12 3.31	—0.19	+31 24 15.6	+ 1.1	" " 258
10	19 45 50.05	+1.52	+10 8 55.1	+ 8.8	" " XIX. 1118
11	0 44 2.44	+2.72	+35 30 12.0	+28.2	B.B. VI. [illegible]
12	*0 15 21.26	+2.70	+35 15 30.8	+28.2	Weisse's Bessel O. [illegible]

OBSERVATIONS OF COMET e 1892 [illegible].

MADE WITH THE 12-INCH [illegible] OF THE LICK OBSERVATORY,

BY E. E. BARNARD.

1892 Mt. Hamilton M.T.	*	No. Comp.	Δα	Δδ	α	δ	
Oct. 22 9 32 33	1	2		[illegible]		[illegible]	[illegible]
9 41 7	1	4	[illegible] 58.15		[illegible]		
24 7 9 37	2	*3 , 4	+0 2.90	[illegible]	[illegible]	[illegible]	
7 35 2	3	*3 , 4	+3 32.15	+10 4[illegible].7	[illegible]	[illegible]	
Nov. 21 6 37 31	4	*3 , 5	+7 17.56	[illegible]	[illegible]	[illegible]	[illegible]

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	15 55 32.87	+1.53	+9 10 7.4	+8.5	Schjellerup 7710
2	19 59 16.	+1.54	+8 29.1	+8.0	10m
3	19 55 45.62	+1.51	+8 15 46.1	+8.0	Lalande 38199
4	21 12 26.65	+1.72	−0 17 0.9	+8.4	Schjellerup 8605 (p.m. not applied)

* Δα measured direct.

Comet very faint in all the observations. Nov. 21, excessively faint and diluted. Further observations will be impossible.

Mt. Hamilton, 1892 *Nov.* 26.

FILAR-MICROMETER OBSERVATIONS OF COMET *f* 1892 (*HOLMES*),

MADE AT THE HAVERFORD COLLEGE OBSERVATORY WITH THE 10-INCH EQUATORIAL,

BY WM. H. COLLINS AND GEO. L. JONES.

1892 Haverford M.T.		*	No. Comp.	☄ — *		☄'s apparent		log pΔ		Obs.
				Δα	Δδ	α	δ	for α	for δ	
	h m s			m s	′ ″	h m s	° ′ ″			
Nov. 13	11 15 36	1	6 , 3	−6 54.42	−2 36.4	0 43 54.04	+37 52 38.7	9.746	0.546	C
	" " "	2	6 , 3	−3 5.53	−5 32.0	0 43 53.88	+37 52 38.9	9.746	0.546	C
16	11 15 57	3	8 , 5	−2 21.14	+6 59.8	0 42 58.13	+37 34 46.8	n9.587	0.051	J
	" " "	4	8 , 5	−0 12.31	−2 19.5	0 42 58.18	+37 34 46.6	n9.587	0.051	J
18	12 15 32	3	4 , 5	−2 48.03	−5 56.9	0 42 31.24	+37 21 50.1	n9.652	0.339	C
21	11 31 9	5	10 , 5	+0 20.71	−0 3.1	0 42 11.20	+37 2 52.0	n9.594	0.062	J
23	12 4 21	6	2 , 3	−5 31.19	−0 52.3	0 42 4.00	+36 49 35.4	n9.661	0.385	J

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 50 45.48	+2.98	+37 51 48.7	+26.4	American Ephemeris 1892
2	0 46 56.43	+2.98	+37 57 14.4	+26.4	Yarnall (F.) 450
3	0 45 16.32	+2.95	+37 27 20.4	+26.6	Weisse's Bessel O, 1116
4	0 43 37.57	+2.95	+37 36 58.9	+26.6	Lalande 1323
5	0 41 47.60	+2.86	+37 2 28.2	+26.9	Weisse's Bessel O, 1029
6	0 47 32.29	+2.90	+36 50 0.4	+27.3	Weisse's Bessel O, 1172

Observation of Nov. 23 stopped by clouds.

OBSERVATIONS OF COMET *f* 1892 (*HOLMES*),

MADE AT THE DUDLEY OBSERVATORY, ALBANY,

BY W. O. LAY

1892 Albany M.T.		*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Nov. 18	12 58 10	1	30 , 10	−0 36.12	+1 41.9	0 42 31.67	+37 21 37.2	9.686	0.466
20	6 33 10	2	26 , 6	−2 16.79	−0 20.4	0 42 15.10	+37 10 41.3	n9.459	0.148
Dec. 9	11 28 14	3	14	+0 39.55	. . . .	0 46 6.86	. . . .	9.663	. . .
	11 9 30		5	. . . .	+1 45.5	. . . .	+35 18 45.6	. . .	0.434
15	10 23 56	4	23	. . . .	. . . .	0 49 35.37	. . . .	9.601	. . .
	10 0 50		8	. . . .	+0 50.7	. . . .	+34 49 44.1	. . .	0.338
20	8 35 57	5	19 , 6	−0 57.25	+2 33.5	0 53 11.72	+34 29 57.8	9.360	0.202

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 43 4.87	+2.91	+37 19 25.9	+26.9	Compared with Lal. 1384
2	0 44 29.00	+2.89	+37 10 34.7	+2[illegible].0	Lund (3 obs.)
3	0 45 21.60	+2.71	+35 15 31.9	+28.2	Lund (2 obs.), Leiden (2 obs.)
4	0 50 59.36	+2.66	+34 48 25.4	+28.0	Leiden (2 obs.)
5	0 54 6.32	+2.65	+34 26 56.2	+28.1	Leiden (2 obs.)

Note. — *1 — Lal. 1384 Δα = −2ᵐ 11ˢ.91; Δδ = −7′ 55″.2

On December 20, the comet appeared like an extremely faint star slightly out of focus. [illegible] appeared nearly as bright.

ON THE COMET *g* 1892 (*BROOKS*).

BY J. G. PORTER.

I send two observations of Comet *g* 1892, which seems to be running away from the ephemeris.

1892 Cincinnati M.T.	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ	log pΔ
h m s			m s	′ ″	h m s	° ′ ″		
Dec. 17 15 38 16	1	8, 6	−0 58.01	+13 10.4	14 1 5.16	+35 30 51.2	*n*9.718	[illegible]
20 13 0 23	2	10, 8	−0 44.57	+ 5 19.7	14 16 32.22	+40 8 34.9	*n*9.754	0.754

Mean Places for 1892.0 of Comparison-Stars.

*	α	Reduction	δ	Reduction	Authority
	h m s	s	° ′ ″	″	
1	14 2 1.83	+1.34	+35 17 37.0	−26.2	Lund A.G. 2 and P[illegible]
2	14 17 15.57	+1.22	+40 3 12.9	−27.7	Weisse's Bessel XIV.[illegible]

From the observations at Cambridge, Nov. 21, Cincinnati, Nov. 30 and Dec. 1, I find the following elements.

T = 1893 Jan. 6.4710 Berlin M.T.

$$\left.\begin{aligned}\omega &= 81^\circ\ 45'.6\\ \Omega &= 185\ \ 22.8\\ i &= 143\ \ 39.5\end{aligned}\right\}\ 1892.0$$

$\log q = 0.07860$

These represent the observation of December 20, as follows:

$$(O-C)$$

$$\Delta\alpha = +8^s, \qquad \Delta\delta = +0'.4$$

EPHEMERIS OF COMET *g* 1892.

BY GEO. L. WHITAKER.

(From Elements by Prof. J. G. Porter.)

Gr. M.T.	App. α	App. δ	log *r*	log Δ	Br.	Gr. M.T.	App. α	App. δ	log *r*	log Δ	Br.
	h m s	° ′					h m s	° ′			
Jan. 1.5	16 11 55	+62 19.6	0.0795	9.8501	7.5	Jan. 12.5	21 37 45	+60 1.5	[illegible]	[illegible]	[illegible]
2.5	17 10 14	63 45.3				13.5	21 53 46	58 29.8	[illegible]	[illegible]	[illegible]
3.5	17 38 13	64 51.2	.0789	.8175	7.6	14.5	22 [illegible]	56 56.7			
4.5	18 8 13	65 37.1				15.5	22 2[illegible] 12	[illegible] 22.8	[illegible]	[illegible]	[illegible]
5.5	18 39 16	66 1.8	.0786	.8408	7.5	16.5	22 [illegible] 7	[illegible]			
6.5	19 10 31	66 2.3				17.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7.5	19 40 51	65 40.9	.0786	.8572	7.3	18.5	22 49 22	[illegible]			
8.5	20 9 10	64 59.1				19.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9.5	20 35 23	64 1.1	.0789	.8690	6.9	20.5	[illegible]	[illegible]			
10.5	20 58 46	62 49.9				21.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.5	21 19 31	+61 28.6	0.0795	9.8845	6.4						

NEW ASTEROIDS.

Prof. **Kreutz** sends notice of two more small planets photographed by Charlois at Nice, [illegible] other Dec. 9 and 10. They were observed as follows:

S. Dec. 10, 7ʰ 51ᵐ.4 Nice M.T. α = [illegible] δ = [illegible]
Daily motion, −15ˢ in α, −2′ in δ. [illegible]

T. Dec. 11, 7ʰ 31ᵐ.0 Nice M.T. α = [illegible] δ = [illegible]
Daily motion, −[illegible] in α, [illegible] in δ. [illegible]

ASTRONOMICAL JOURNAL PRIZES.

A gentleman, earnestly interested in the development and progress of astronomy in his native land, has authorized the editor of this Journal to offer two prizes, for resident citizens of the United States.

He expresses the hope that it may be possible to offer similar prizes in subsequent years, although only two are proposed at present, the requisite amount for these having been placed at the editor's disposal.

They will be known as *Astronomical Journal Prizes*, and will be given either in money, or in the form of a suitable gold medal of the value of two hundred dollars, with the remainder, if any, in money, at the option of the recipient.

The awards will be made by a commission of three judges, to be selected from American astronomers, and their names to be announced in due time.

The prizes now offered are for researches tending to advance our knowledge of cometary orbits, and are these.

I.

For the observer making the best series of determinations of the positions of comets during the year ending on the thirty-first of March, 1894, a prize of two hundred dollars. The conditions to be considered in the award will be the accuracy of measurement and reduction, the number of the observations and their judicious distribution along the geocentric paths, and the promptitude of their publication. To equalize the claims of observers, due allowance will be made for the different optical powers of the telescopes used. Also, since there seems to have been a tendency to neglect such comets as are observable only in the morning, regard is to be had, in the award, to the especial usefulness of observations made at inconvenient hours.

II.

For the best discussion of the path of a periodic comet, with due regard to its perturbations, of the kind ordinarily known as the definitive determination of the orbit, a prize of four hundred dollars. The investigation must, however, have been made within the two years next preceding 1894 Sept. 1; and the manuscript (which will be returned to the author) transmitted, not later than that date, to some one of the judges.

In these awards it will be left to the discretion of the judges to decide whether in case of uncertainty on account of nearly equal claims of two candidates, either of the prizes ought to be divided. Also, in case that either award should not, in their opinion, be fully justified, they will be authorized to withhold the same; in which event it will be offered again, under the same conditions, for the next ensuing year.

Should similar prizes be offered in the coming year, it is intended that one of them shall be for the best series of determinations of maxima and minima of variable stars during the years 1893 and 1894.

A CORRECTION.

A remark of Dr. BAUSCHINGER calls my attention to an error in my observation of Comet *d* 1889 (BROOKS); see *A.J.*, no. 209, p. 135, The value of $\Delta\alpha$ should be $-1^m\ 26^s.67$ and hence $\alpha = 0^h\ 15^m\ 12^s.82$. This correction had already been made in the observing book, and I regret it was not published before.

1892 *December* 21.

A. HALL.

CORRIGENDUM.

No. 279, p. 115, col. 2, value of *B*, the factor in brackets should be squared.

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MICROMETER MEASURES OF THE FIFTH SATELLITE OF *JUPITER*,

MADE WITH THE 36-INCH EQUATORIAL OF THE LICK OBSERVATORY

BY E. E. BARNARD.

Continued from A. J. N°. 275.

In the *Astronomical Journal*, No. 275, I have given a historical account of the discovery of the fifth satellite of *Jupiter* along with a set of micrometer measures of its position on the dates, Sept. 9, 10, 11, 12, 13, 14 and 16, 1892.

These measures I have continued when the opportunity afforded. They have all been made through a piece of smoked mica placed in front of the field lens of the eye-piece.

Believing that observations of the satellite, for this year at least, would rest almost alone upon my efforts, I have secured as many measures as possible upon the nights that I have observed it. By so doing, the satellite has been observed throughout a large portion of its orbit. These measures I give in detail, as hereafter all the investigations of the motion of the satellite will doubtless rest entirely on them as a basis.

Under favorable conditions a single measure of the satellite's position with the great telescope could be made with an accuracy considerably under a second of arc. The delicate and adjustable illumination of the wires by BURNHAM's method permits the most accurate bisection of the faintest object that can be seen.

In observing with a great telescope, however, there are other things to be taken into account besides the difficulty of seeing the object and of properly illuminating the wires. The greatest enemy here to accurate measures is the wind. This is to be more dreaded even, where the distance is great, and where the eye cannot take in both objects at the same glance, than when the distance is very small, especially where one of the objects is faint.

The vast amount of work, and the accuracy of the results obtained by the indefatigable labors of Mr. BURNHAM with the 36-inch, have already shown the world that the great Lick Refractor is not only the most powerful telescope in existence, but that it is also one of the most perfect, and my own experience with it leads me to corroborate this testimony. Therefore the following remarks must in no wise be taken as a criticism of the 36-[illegible] A[illegible] exposed position of Mt. Hamilton [illegible] winds prevailing night after night [illegible] of the observing weather [illegible]. When it is necessary to face these winds, as it has been the case [illegible] vations of this new satellite of *Jupiter*, the great [illegible] the telescope exposed to them causes a constant [illegible] of the tube, the image oscillating over [illegible] space of from 10″ to 40″ or 50″ of arc [illegible] very difficult, and often impossible to bisect two [illegible] separated by a half minute of arc.

This is the era of great telescopes, and any suggestions that may lead to remedying these evils [illegible] will be valuable. I would therefore suggest [illegible] struction of domes for large refractors [illegible] screen be introduced in the observing slit [illegible] direct wind from the tube [illegible] the slit [illegible] able. This is not a difficult thing to do. A system of canvas curtains running across the slit [illegible] wires would be serviceable, or a canvas [illegible] from a roll at the base of the dome [illegible] direct impact of the wind upon the tube. [illegible] new dome, a thin sheet [illegible] arranged, with suitable [illegible] grooves in the side of the observing slit [illegible] than half way [illegible]

O[illegible] great [illegible] exposed to [illegible] [illegible] observ[illegible] I [illegible] [illegible] of [illegible]

Mr. BURNHAM [illegible] observer.

In [illegible] I [illegible]

measured the equatorial and polar diameters of *Jupiter* (by the method of double distances) for use in deducing the Jovicentric distances and latitudes of the satellite.

These measures afford us a new determination of the Jovian diameters, and I have collected them here, and have also reduced the apparent measures to distance 5.20 for comparison.

Perhaps it would have been better to have used the final values of the diameters from my observations in reducing all the measures of the position of the satellite, but I have thought perhaps it would be best to let them stand, based as they are, upon the diameter-measures for the night, as everything would then rest upon the same conditions for seeing, etc., belonging to the night of observation.

The diameters are not corrected for phase.

OBSERVED EQUATORIAL AND POLAR DIAMETERS OF *Jupiter*.

1892			Equatorial Diam		Polar Diam.	
			Appt.	5.20	Appt.	5.20
	d	h	"	"	"	
Sept.	10	14.5	48.93	38.17	. .	. .
	11	13.5	49.41	38.54	. .	. .
	12	14.0	48.97	38.33	46.01	36.01
	13	12.5	. .	. .	46.10	36.03
	14	12.0	49.18	38.34	46.03	35.83
	16	12.0	49.98	38.85	46.57	36.20
	23	11.5	50.24	38.61	47.36	36.42
	25	17.0	50.26	38.50	. .	. .
	27	12.5	. .	.	47.25	36.17
Oct.	1	13.0	50.26	38.34	. .	. .
	2	13.0	50.20	38.30	. .	. .
	7	10.0–14.0	50.51	38.42	46.93	35.70
	9	11.5	50.80	38.62	. .	. .
	16	12.5–14.0	50.25	38.25	48.13	36.64
	21	11.0	49.95	38.44	46.90	35.81
	23	10.0	49.81	38.07	46.85	35.80
	28	9.2–10.2	48.89	38.38	46.66	35.90
Nov.	4	8.7– 9.5	49.18	38.25	45.87	35.68
	6	9.0	49.15	38.45	. .	. .
	11	8.0	48.53	38.35	45.93	36.30
	13	8.0	48.29	38.27	. .	. .
	20	8.5– 7.7	47.40	38.15	44.72	35.99
				38.382		36.034
				±0.028		±0.051

The probable error of a single determination being 0".13 and 0".19 respectively.

The above measures, except Sept. 10–11, were made through smoked mica. They give for the diameters of *Jupiter* the following values:

Equatorial diameter 89790 ± 65 miles.
Polar diameter 84300 ± 80 miles.

I had previously measured the diameters of the planet with the great telescope, and insert them separately here, as they were not made through any obscuring medium.

OBSERVED EQUATORIAL AND POLAR DIAMETERS OF *Jupiter*.

1892			Equatorial Diam		Polar Diam.	
			Appt.	5.20	Appt.	5.20
	d	h		"	"	"
July	8	15.5	40.41	38.52	38.19	36.37
	15	15.7	41.37	38.55	. .	. .
	22	15.6	42.27	38.52	39.87	36.34
	29	15.0	43.00	38.31	40.85	36.40
Aug.	5	15.5	44.08	38.40	41.58	36.22
	12	15.5	44.78	38.16	42.83	36.50
				38.410		36.366

These give for the diameters of *Jupiter*,

Equatorial diameter 89860 miles.
Polar diameter 85080 miles.

From the numerous determinations of the parallel of the belts, I have deduced the following position-angles of planet's equator, which will give an independent value for this quantity, for the final investigation of the orbit of the satellite.

They were made in nearly every case when the planet was not far from the meridian, and as the parallel was determined near the point of observation, they hence need no correction for refraction.

I have collected these observations below:

OBSERVED POSITION-ANGLES OF THE BELTS OF *Jupiter*, 1892.

						°	
Sept.	10	67.1	3 obs.	Oct.	9	66.9	3 obs.
	11	66.7	5 obs.		16	66.6	2 obs.
	12	66.6	5 obs.		21	66.7	2 obs.
	13	67.4	1 obs.		23	66.2	4 obs.
	14	67.0	3 obs.		28	66.1	4 obs.
	16	66.8	1 obs.	Nov.	4	66.2	3 obs.
	23	67.1	4 obs.		6	65.7	5 obs.
	25	66.5	1 obs.		11	65.5	4 obs.
	27	66.5	2 obs.		13	65.6	4 obs.
Oct.	1	66.5	1 obs.		18	66.6	1 obs.
	2	67.0	4 obs.		20	65.2	4 obs.
	7	66.8	2 obs.	Dec.	16	65.6	4 obs.

I have collected in a table here the different values of the coincidence of the threads of the micrometer as determined during the observations of the satellite, and used in the reduction of the measures.

		r			r
Sept.	23	29.009	Oct.	21	29.005
	25	29.009		23	29.012
	27	29.008		28	29.011
Oct.	1	29.008	Nov.	4	29.011
	2	29.014		6	29.309
	7	29.011		11	29.299
	9	29.001		13	29.299
	16	28.993		18	29.291
	17	28.994		20	29.291

The observations which follow are all in Standard Pacific Time, which is 8 hours slow of Greenwich, and consequently the Greenwich Mean Time is obtained by simply adding 8 hours to the recorded times.

In all the observations the polar distances were measured by first placing the wires carefully parallel to the belts of

Jupiter. The values ♃β are simply the differences between the polar distance of the satellite and the measured semi-polar diameter.

The distances from the following and preceding limbs were made by placing the wires perpendicular to the belts by aid of the position-circle.

No correction for refraction has been applied to any of the measures. It is mostly insensible, and scarcely exceeds 0″.01 in the extreme cases.

September 23.

From North limb — Satellite following.

h m s	r	″	♃ β
10 8 5	31.189	21.59	+ 2.09
10 10 15	31.175	21.45	2.23
10 11 15	31.162	21.32	2.36
10 13 2	31.145	21.15	2.53
10 15 10	31.089	20.60	+ 3.08

From South limb.

10 17 20	26.425	25.59	+ 1.91
10 19 50	26.442	25.42	1.74
10 22 57	26.535	24.50	0.82
10 25 20	26.484	25.03	1.35
10 29 15	26.518	24.67	+ 0.99

From South limb.

12 36 42	26.733	22.54	— 1.14
12 37 44	26.759	22.28	1.40
12 39 42	26.725	22.62	— 1.06

From North limb.

12 40 32	31.614	25.79	— 2.11
12 41 37	31.439	24.06	0.38
12 42 47	31.511	24.77	— 1.09
12 43 52	31.382	23.50	+ 0.18

Satellite following.

		From F. limb	From center
10 41 50	25.878	31.00	56.12
10 43 45	25.800	31.77	56.89
10 45 0	25.861	31.17	56.29
10 46 25	25.797	31.80	56.92
10 48 40	25.830	31.48	56.60
10 49 45	26.768	32.09	57.21
10 52 43	25.630	33.46	58.58
10 54 45	25.659	33.17	58.29
10 57 10	25.618	33.58	58.70
10 58 27	25.560	34.15	59.27
11 4 14	25.435	35.39	60.51
11 5 50	25.410	35.64	60.76
11 8 10	25.436	35.39	60.51
11 9 55	25.400	35.74	60.86
11 11 23	25.428	35.46	60.58
11 12 29	25.341	36.32	61.44
11 13 40	25.371	36.02	61.14
11 15 32	25.217	37.25	62.37
11 16 10	25.275	36.97	62.09
11 16 15	25.245	37.27	62.39
11 17 42	25.325	36.48	61.60
11 18 40	25.356	36.17	61.29
11 21 17	25.265	37.07	62.19
11 22 3	25.196	37.76	62.88

Satellite following [illegible]

		From F. limb	From center
11 23 7	25.24[illegible]	37.[illegible]	[illegible]
11 24 6	25.327	36.16	[illegible]
11 24 55	25.238	37.34	[illegible]
11 25 57	25.219	37.23	[illegible]
11 27 32	25.251	37.21	[illegible]
11 28 32	25.209	37.5[illegible]	[illegible]
11 29 55	25.311	36.59	[illegible]
11 32 30	25.247	37.25	[illegible]
11 33 12	25.253	37.19	[illegible]
11 35 15	25.195	37.77	[illegible]
11 35 12	25.206	36.77	[illegible]
11 39 17	25.209	36.71	[illegible]
11 41 32	25.180	37.91	[illegible]
11 42 52	25.251	37.21	[illegible]
11 45 32	25.269	37.0[illegible]	62
11 47 17	25.218	37.21	[illegible]
11 48 52	25.365	36.08	[illegible]
11 50 57	25.286	[illegible].86	[illegible]
11 52 12	25.298	36.75	61.87
11 53 42	25.273	36.99	62.1[illegible]
11 57 2	25.425	35.49	[illegible]
11 57 57	25.345	36.28	[illegible]
11 59 12	25.265	37.07	[illegible]
12 0 17	25.478	34.96	[illegible]
12 1 2	25.265	37.07	[illegible]
12 7 17	25.336	36.37	[illegible]
12 9 22	25.453	35.21	[illegible]
12 10 22	25.491	34.84	[illegible]
12 11 35	25.585	34.10	[illegible]
12 16 17	25.621	33.72	[illegible]
12 17 29	25.611	33.32	[illegible]
12 23 12	25.702	31.86	[illegible]

Sept. 23. Seeing very poor. High wind.

September 25.

Satellite preceding.

		From W. [illegible] limb	[illegible]
16 38 40	32.271	32.28	57.[illegible]
16 42 15	32.180	31.37	[illegible]
16 48 10	32.453	34.10	[illegible]
16 50 10	32.633	[illegible]5.88	61[illegible]
16 51 55	32.410	33.08	[illegible]
16 53 50	32.605	35.63	[illegible]
16 57 20	32.580	35.36	[illegible]
17 19 50	32.881	38.[illegible]	[illegible]

Sept. 25. Satellite very faint. [illegible]

September 27.

From North limb — Satellite following.

			♃
9 48 8	31.[illegible]81	21.[illegible]	+ 2.[illegible]
9 49 26	31.095	20.67	[illegible]
9 50 58	31.196	21.67	[illegible]
9 51 18	31.205	21.76	[illegible]
9 53 3	31.177	21.48	+ 2.[illegible]

From South limb.

9 54 35	26.408	2[illegible].74	+ 2.[illegible]
9 55 35	26.364	26.18	2.[illegible]6
9 56 20	26.464	25.19	1.[illegible]7
9 57 13	26.460	25.23	1.64
9 58 10	26.455	25.48	+ 1.86

From North limb.

h m s	r	″	♃ δ ″
10 4 48	31.175	21.46	+ 2.16
10 7 58	31.132	21.03	2.59
10 8 48	31.271	22.41	1.21
10 9 48	31.234	22.04	1.58
10 10 33	31.277	22.47	+ 1.15

From South limb.

h m s	r	″	♃ δ ″
10 13 43	26.383	25.99	+ 2.37
10 14 28	26.506	24.77	1.15
10 15 23	26.465	25.18	1.56
10 16 23	26.389	25.93	2.31
10 16 53	26.457	25.26	+ 1.64

From North limb

h m s	r	″	♃ δ ″
12 13 10	31.611	25.80	— 2.18
12 15 25	31.529	24.96	1.34
12 17 55	31.598	25.65	2.03
12 19 5	31.607	25.73	2.11
12 20 5	31.629	26.05	— 2.43

From South limb.

h m s	r	″	♃ δ ″
12 21 50	26.862	21.25	— 2.37
12 22 37	26.875	21.12	2.50
12 23 32	26.851	21.36	2.26
12 24 20	26.835	21.52	2.10
12 25 25	26.791	21.95	— 1.67

From South limb.

h m s	r	″	♃ δ ″
12 39 40	26.861	21.26	— 2.36
12 41 20	26.943	20.45	3.17
12 42 25	26.903	20.84	2.78
12 44 27	26.978	20.10	— 3.52

From North limb.

h m s	r	″	♃ δ ″
12 46 5	31.710	26.76	— 3.14
12 48 12	31.722	26.87	3.25
12 49 50	31.663	26.29	2.67
12 51 10	31.764	27.29	3.67
12 54 50	31.718	26.83	— 3.21

Satellite following.

h m s	r	From E. limb ″	From center ″
10 22 48	32.295	32.55	57.72
10 24 11	32.199	31.60	56.77
10 25 10	32.300	32.60	57.77
10 26 25	32.335	32.94	58.11
10 28 0	32.403	33.62	58.79
10 29 8	32.406	33.65	58.82
10 30 23	32.420	33.79	58.96
10 31 18	32.374	33.33	58.50
10 32 30	32.481	34.39	59.56
10 33 23	32.441	33.99	59.16
10 34 33	32.399	33.58	58.75
10 35 41	32.465	34.23	59.40
10 37 33	32.513	34.71	59.88
10 38 40	32.562	35.19	60.36
10 40 5	32.585	35.42	60.59
10 41 25	32.674	36.30	61.47
10 42 33	32.554	35.11	60.28
10 43 53	32.612	35.69	60.86
10 46 15	32.682	36.38	61.55
10 50 11	32.724	36.80	61.97
10 51 50	32.675	36.31	61.48
10 36 43	32.489	34.47	59.64
10 53 10	32.732	36.87	62.04
10 54 52	32.724	36.80	61.97

Satellite following. — *cont.*

h m s	r	From E. limb ″	From center ″
10 56 7	32.739	36.94	62.11
10 58 40	32.742	36.97	62.14
10 59 57	32.781	37.36	62.53
11 3 3	32.770	37.25	62.42
11 4 8	32.813	37.68	62.85
11 5 6	32.810	37.65	62.82
11 6 27	32.888	38.42	63.59
11 7 55	32.887	38.41	63.58
11 9 10	32.874	38.28	63.45
11 10 42	32.822	37.77	62.94
11 12 22	32.889	38.43	63.60
11 14 55	32.834	37.89	63.06
11 21 30	32.795	37.50	62.67
11 22 25	32.754	37.09	62.26
11 23 55	32.878	38.32	63.49
11 26 15	32.782	37.37	62.54
11 28 15	32.765	37.20	62.37
11 31 25	32.756	37.11	62.28
11 36 10	32.633	35.89	61.06
11 38 10	32.710	36.66	61.83
11 39 10	32.712	36.68	61.85
11 42 3	32.655	36.11	61.28
11 43 26	32.653	36.09	61.26
11 44 15	32.558	35.15	60.32
11 45 45	32.590	35.47	60.64
11 46 40	32.562	35.19	60.36
11 48 5	32.468	34.26	59.43
11 51 0	32.468	34.26	59.43

Sept. 27 Wind shaking telescope.

October 1.

Satellite following.

h m s	r	From E. limb ″	From center ″
12 13 48	26.666	23.19	48.32
12 15 55	26.936	20.52	45.65
12 18 0	27.000	19.88	45.01
12 20 10	27.085	19.04	44.17
12 22 12	27.063	19.26	44.39
12 23 45	27.164	18.26	43.39
12 24 53	27.240	17.51	42.64
12 26 52	27.319	16.73	41.86
12 30 5	27.497	14.96	40.09
12 31 55	27.545	14.49	39.62
12 36 40	27.742	12.54	37.67
12 38 25	27.800	11.96	37.09
12 42 27	27.934	10.64	35.77

Satellite preceding.

h m s	r	From E. limb ″	From center ″
15 39 16	31.616	26.12	51.25
15 41 10	31.748	27.13	52.26
15 42 55	31.749	27.14	52.27
15 44 17	31.810	27.75	52.88
15 52 0	31.964	29.27	54.40
15 53 15	32.048	30.10	55.23
15 55 10	32.045	30.07	55.20
15 56 37	32.124	30.86	55.98
15 58 20	32.172	31.33	56.46
16 0 0	32.213	31.74	56.87
16 4 22	32.303	32.63	57.76
16 5 23	32.319	32.79	57.92
16 7 40	32.283	32.43	57.56

Oct. 1. Poor seeing, and wind shaking telescope.

October 2.

Satellite following.

h m s	r	From E. limb	From center
9 22 2	26.790	22.02	47.12
9 25 40	26.643	23.48	48.59
9 27 25	26.709	22.82	47.92
11 48 14	26.182	28.01	53.11
11 49 50	26.037	29.48	54.58
11 52 7	26.223	27.61	52.71
11 54 25	26.333	26.55	51.65
11 56 15	26.228	27.59	52.69
11 57 15	26.412	25.76	50.86
11 58 50	26.412	25.76	50.86
12 0 2	26.538	24.52	49.62
12 3 32	26.539	24.51	49.61
12 6 45	26.689	23.02	48.12
12 8 40	26.791	22.01	47.11
12 12 3	26.982	20.12	45.22
12 13 13	26.953	20.41	45.51
12 14 50	27.049	19.46	44.56
12 16 25	26.965	20.29	45.39
12 18 47	27.155	18.41	43.51
12 20 48	27.325	16.73	41.83
12 22 30	27.339	16.58	41.68
12 26 35	27.512	14.87	39.97
12 28 15	27.558	14.42	39.52
12 29 50	27.662	13.39	38.49
12 31 33	27.765	12.37	37.47
12 32 47	27.809	11.93	37.03
12 35 35	27.889	11.14	36.24
12 37 8	28.045	9.59	34.69
12 39 27	28.195	8.11	33.21

Satellite preceding.

h m s	r	From W. limb	From center
15 7 52	30.679	16.49	41.59
15 9 25	30.728	16.97	42.07
15 11 2	30.909	18.77	43.87
15 12 35	30.830	17.98	43.08
15 13 45	30.810	17.79	42.89
15 14 34	30.961	19.28	44.38
15 15 55	31.050	20.16	45.25
15 17 10	31.050	20.16	45.25
15 20 26	31.175	21.40	46.50
15 22 25	31.293	22.57	47.67
15 23 27	31.220	21.84	46.94
15 24 46	31.312	22.76	47.86
15 26 8	31.442	24.04	49.14
15 28 40	31.466	24.28	49.38
15 33 56	31.656	26.16	51.26
15 35 20	31.734	26.93	52.03
15 37 15	31.759	27.18	52.28
15 46 6	31.989	29.46	54.56

Oct. 2. Seeing very poor and wind shaking telescope.

October 7.

Satellite following.

h m s	r	From W. limb	From center
8 44 55	27.378	16.17	41.42
8 44 50	27.170	18.23	43.48
8 46 10	27.168	18.25	43.50
8 47 25	27.077	19.15	44.40
8 49 40	26.921	20.69	45.94
9 7 5	26.390	25.95	51.20

Satellite following [illegible]

h m s	r	From W. limb	From center
9 8 30	26.323	26.62	51.87
9 9 12	26.303	26.81	52.06
9 10 40	26.250	27.34	52.59
9 12 10	26.219	27.65	52.60
9 13 50	26.140	28.43	[illegible]
9 44 30	25.472	35.04	[illegible]
9 46 2	25.398	35.78	61.03
9 47 15	25.362	36.13	61.38
9 48 30	25.482	34.94	[illegible]
9 50 0	25.261	37.10	62.35
9 51 7	25.409	35.67	60.92
9 52 5	25.351	36.24	61.49
9 53 2	25.258	37.16	62.41
9 54 30	25.299	36.76	62.01
9 57 25	25.241	37.33	62.58
9 58 40	25.191	37.83	63.08
10 0 0	25.225	37.49	62.74
10 2 3	25.224	37.50	62.75
10 4 3	25.198	37.76	63.01
10 5 27	25.214	37.60	62.85
10 7 17	25.221	37.53	62.78
10 8 42	25.185	37.89	63.14
10 10 25	25.190	37.84	63.09
10 12 15	25.218	37.56	62.81
10 13 25	25.178	37.95	63.20
10 15 14	25.189	37.85	63.10
10 17 5	25.098	38.75	[illegible]
10 18 18	25.192	37.81	[illegible]
10 19 25	25.073	38.97	64.22
10 21 0	25.075	38.97	64.22
10 23 0	25.275	36.99	62.24
10 23 45	27.158	38.15	[illegible]
10 24 15	25.275	36.99	62.24
10 25 35	25.114	38.59	[illegible]
10 26 45	25.144	38.29	[illegible]
10 28 5	25.157	38.16	[illegible]
10 29 20	25.192	37.82	[illegible]
10 30 40	25.203	37.71	[illegible]
10 32 15	25.188	37.86	[illegible]
10 34 17	25.213	37.61	62.86
10 35 45	25.253	37.21	62.46
10 38 5	25.224	37.50	62.75
10 42 4	25.195	37.79	[illegible]
10 42 25	[illegible]	36.42	[illegible]
10 44 5	25.317	36.58	[illegible]
10 46 37	[illegible]	[illegible]	[illegible]
10 49 5	25.461	35.15	[illegible]
11 49 29	[illegible]	[illegible]	[illegible]
11 51 7	[illegible]	18.41	[illegible]
11 51 55	27.216	17.78	[illegible]
11 53 2	27.173	18.20	[illegible]
11 54 50	27.209	[illegible]	[illegible]
11 55 27	27.313	16.82	[illegible]
11 57 45	[illegible]	15.14	[illegible]
12 42 35	28.172	8.33	[illegible]
12 44 50	28.115	8.87	[illegible]

From South limb. Satellite [illegible] to [illegible]

h m s	r		
8 53 58	26.229	27.0[illegible]	[illegible]
8 54 46	26.229	27.1[illegible]	[illegible]
8 56 17	26.333	26.7[illegible]	[illegible]
8 57 12	26.2[illegible]	26.9[illegible]	[illegible]
8 58 2	26.324	26.61	[illegible]

From North limb (Satellite following). — *cont.*

h m s	r		♃ 3 "
8 59 27	31.272	23.39	+ 1.07
9 0 25	31.453	24.24	2.25
9 1 30	31.224	21.88	1.58
9 2 45	31.234	22.04	1.45
9 3 2	31.204	21.74	+ 1.75

From South limb.

12 3 0	26.862	24.28	— 2.18
12 4 20	26.829	24.63	1.83
12 5 45	26.794	24.95	— 1.54

From North limb.

12 7 45	31.603	25.67	— 2.24
12 8 20	31.565	25.27	1.84
12 9 27	31.604	25.65	— 2.19

Oct. 8. Wind shaking telescope at eastern observations of the satellite but steady at the western observations.

October 9.

Satellite following.

		From E. limb	From center
9 53 20	25.153	38.10	63.50
9 54 50	25.213	37.51	62.91
9 56 35	25.164	37.99	63.39
9 58 52	25.155	38.08	63.48
10 10 45	25.341	36.24	61.64
10 13 0	25.558	34.09	59.49
10 15 22	25.612	33.56	58.96
10 17 20	25.519	34.48	59.88
10 51 10	25.633	33.35	58.75
10 53 15	25.738	32.31	57.71
10 59 20	25.818	31.22	56.62
11 3 25	26.015	29.57	54.97

Satellite preceding.

		From E. limb	From center
14 31 3	35.932	68.63	43.23
14 33 5	35.939	68.70	43.30
14 34 3	35.903	68.34	42.94
14 36 33	36.202	71.30	45.90
14 38 35	36.273	72.01	46.60
14 40 2	36.223	71.51	46.11
14 42 1	36.295	72.23	46.83

		From W. limb	From center
14 44 10	31.289	22.66	48.06
14 46 10	31.169	21.47	46.87
14 47 37	31.319	22.95	48.35
14 48 57	31.358	23.31	48.71
14 50 35	31.388	23.65	49.05
14 57 35	31.708	26.81	52.21
14 59 5	31.625	25.98	51.38
15 1 55	31.721	26.93	52.33
15 4 15	31.925	28.95	54.35
15 6 5	31.971	29.41	54.81
15 7 45	31.990	29.60	55.00
15 13 15	32.076	30.45	55.85
15 20 40	32.245	32.12	57.52
15 22 20	32.279	32.46	57.86
15 24 20	32.329	32.96	58.35
15 30 45	32.377	33.43	58.83
15 31 0	32.378	33.44	58.84
15 33 0	32.570	35.25	60.65

h m s	r	From W. limb "	From center "
15 34 2	32.499	34.64	60.04
15 35 10	32.446	34.11	59.51
15 37 2	32.533	34.97	60.37
15 40 50	32.575	35.39	60.79
15 42 35	32.683	36.46	61.86
15 45 17	32.707	36.70	62.10
15 47 7	32.670	36.33	61.73
15 50 15	32.684	36.47	61.87
15 51 50	32.753	37.15	62.55
16 3 20	32.744	36.74	62.14
16 5 2	32.775	37.37	62.77
16 6 53	32.794	37.57	62.97
16 9 55	32.688	36.51	61.91
16 11 35	32.668	36.31	61.71
16 12 46	32.675	36.38	61.78
16 14 5	32.662	36.25	61.65
16 16 20	32.721	36.86	62.26
16 18 55	32.658	36.21	61.61
16 20 40	32.788	37.50	62.90
16 21 40	32.753	37.15	62.55
16 22 40	32.670	36.33	61.73
16 24 30	32.712	36.75	62.15
16 25 37	32.713	36.76	62.16
16 27 20	32.655	36.18	61.58
16 28 40	32.614	35.78	61.18
16 31 30	32.525	34.89	60.29
16 32 45	32.654	36.17	61.57
16 34 28	32.613	35.77	61.17
16 36 20	32.559	35.23	60.63
16 40 30	32.293	32.60	58.00
16 42 35	32.424	33.89	59.29

Oct. 9. Windy. Seeing very bad.

October 16.

Satellite preceding.

		From E. limb	From center
14 10 45	31.445	24.28	49.40
14 12 40	31.552	25.34	50.46
14 19 0	31.713	26.93	52.05
14 21 15	31.552	25.34	50.46
14 39 19	32.228	32.03	57.15
14 43 6	32.039	30.16	55.28
14 44 6	32.301	32.76	57.88
14 47 5	32.383	33.57	58.69
14 48 50	32.460	34.03	59.15
14 50 37	32.364	33.38	58.50
14 51 53	32.404	33.78	58.90
14 53 6	32.417	33.90	59.02
14 54 10	32.488	34.61	59.73

Oct. 16. Satellite very faint. Seeing very poor.

October 17.

From South limb — (Satellite preceding.)

			♃ 3
13 51 24	26.772	22.00	+2.07
13 55 17	26.846	21.27	2.80
13 56 42	26.884	20.89	+3.18

From North limb.

14 0 49	31.633	26.13	+2.06
14 1 57	31.600	25.80	1.73
14 3 22	31.610	25.90	+1.83

Satellite preceding.

h m s	r	From W. limb	From center
14 15 24	31.826	28.01	53.16
14 18 20	31.895	28.73	53.85
14 24 14	31.901	28.79	53.91
14 27 14	31.963	29.40	54.52
14 29 42	32.197	31.72	56.84
14 33 15	32.091	30.67	55.79
14 53 9	32.515	34.86	59.98
14 56 27	32.565	35.36	60.48
15 9 12	32.662	36.32	61.44
15 12 32	32.648	36.18	61.30
15 14 32	32.825	37.93	63.05
15 15 57	32.878	38.46	63.58
15 17 42	32.635	36.05	61.17
15 18 57	32.656	36.26	61.38
15 20 17	32.701	36.71	61.83
15 21 27	32.580	35.51	60.63
15 23 7	32.808	37.77	62.89
15 26 27	32.779	37.48	62.60
15 31 57	32.568	35.39	60.51
15 33 27	32.595	35.65	60.77
15 35 22	32.626	35.96	61.08
15 37 57	32.639	36.09	61.21
15 39 52	32.514	34.86	59.98

Oct. 17. **Satellite very faint.** A high wind shaking the telescope badly.

October 21.

Satellite following.

		From E. limb	From center
7 59 16	26.101	28.73	53.70
8 1 4	25.976	30.01	54.98
8 2 58	25.967	30.08	55.05
8 4 48	25.991	29.84	54.78
8 5 52	25.932	30.43	55.40
8 6 52	25.908	30.67	55.64
8 8 38	25.856	31.18	56.15
8 9 36	25.845	31.29	56.26
8 10 53	25.860	31.14	56.11
8 11 38	25.852	31.22	56.19
8 14 43	25.670	33.02	57.99
8 16 55	25.700	32.73	57.70
8 17 58	25.670	33.02	57.99
8 21 47	25.578	33.93	58.90
8 23 2	25.575	33.96	58.93
8 24 23	25.602	33.70	58.67
8 27 13	25.548	34.23	59.20
8 28 22	25.591	33.81	58.78
8 29 28	25.426	35.44	60.41
8 56 3	25.007	39.59	64.56
9 6 23	25.071	38.96	63.93
9 8 43	25.359	36.10	61.07
9 34 48	25.412	35.58	60.55
9 48 43	25.672	33.00	57.97
9 54 20	25.899	30.76	55.73
10 1 34	26.020	29.56	54.53
10 2 48	26.193	27.84	52.81
10 4 35	26.030	29.46	54.43
10 6 51	26.220	27.58	52.55
10 7 30	26.133	28.44	53.41
10 8 15	26.250	27.28	52.25
10 9 41	26.320	26.59	51.56
10 11 12	26.196	27.28	52.75

Satellite following.

		From E. limb	From center
10 13 [illegible]	[illegible]	[illegible]	[illegible]
10 14 33	26.507	24.74	[illegible]
10 15 21	26.587	[illegible]	[illegible]
10 16 11	[illegible]	[illegible]	[illegible]
10 16 58	26.570	[illegible]	[illegible]
10 17 43	[illegible]	[illegible]	[illegible]
10 18 41	[illegible]	[illegible]	[illegible]
10 19 33	26.552	[illegible]	[illegible]
10 20 18	[illegible]	[illegible]	[illegible]
10 21 28	[illegible]	[illegible]	[illegible]
10 23 38	[illegible]	[illegible]	[illegible]
10 24 20	26.778	22.25	47.22
10 25 8	26.817	21.67	[illegible]
10 26 58	26.869	21.15	[illegible]
10 27 41	26.912	20.72	[illegible]
10 28 35	26.958	20.27	[illegible]
10 29 40	[illegible]	19.54	[illegible]
10 31 3	[illegible]	19.27	[illegible]
10 49 42	27.752	12.11	[illegible]
10 51 1	27.941	10.54	[illegible]
10 52 8	27.870	11.18	[illegible]
10 53 5	27.998	[illegible]	[illegible]
10 53 55	28.041	[illegible]	[illegible]
10 55 3	28.057	[illegible]	[illegible]
10 55 53	28.085	9.11	[illegible]
10 57 13	28.159	[illegible]	[illegible]

Satellite preceding.

		From W. limb	From center
11 15 26	[illegible]	[illegible]	[illegible]
11 18 10	25.614	[illegible]	[illegible]
11 22 50	32.465	34.26	[illegible]
11 24 0	[illegible]	[illegible]	[illegible]
11 24 54	32.439	[illegible]	[illegible]
11 25 50	[illegible]	[illegible]	[illegible]
11 26 40	32.624	[illegible]	[illegible]
11 27 45	[illegible]	[illegible]	[illegible]
11 28 50	32.508	[illegible]	[illegible]
11 30 37	32.580	[illegible]	[illegible]
11 31 55	[illegible]	[illegible]	[illegible]
11 32 5	32.615	[illegible]	[illegible]
11 33 57	[illegible]	[illegible]	[illegible]
11 34 55	32.678	[illegible]	[illegible]
11 35 45	32.657	[illegible]	[illegible]
11 37 [illegible]	[illegible]	[illegible]	[illegible]
11 39 25	[illegible]	[illegible]	[illegible]
11 40 50	[illegible]	[illegible]	[illegible]
11 41 55	[illegible]	[illegible]	[illegible]
11 42 40	32.687	[illegible]	[illegible]
11 43 41	[illegible]	[illegible]	[illegible]
11 44 58	[illegible]	[illegible]	[illegible]
11 45 50	[illegible]	[illegible]	[illegible]
11 46 25	32.677	[illegible]	[illegible]
11 47 7	[illegible]	[illegible]	[illegible]
11 48 41	32.700	[illegible]	[illegible]
11 49 50	[illegible]	[illegible]	[illegible]
11 50 15	[illegible]	[illegible]	[illegible]
11 51 8	32.764	[illegible]	[illegible]
11 52 0	32.688	[illegible]	[illegible]
11 53 40	32.794	[illegible]	[illegible]
11 55 [illegible]	[illegible]	[illegible]	[illegible]
11 56 [illegible]	[illegible]	[illegible]	[illegible]
11 57 [illegible]	[illegible]	[illegible]	[illegible]

Satellite preceding. — *cont.*

		From W. limb	From center
h m s	r	"	"
14 58 30	32.738	36.96	61.93
15 0 5	32.712	36.71	61.68
15 1 13	32.761	37.19	62.16
15 1 37	32.844	38.01	62.98
15 3 35	32.752	37.10	62.07
15 4 37	32.771	37.29	62.26
15 6 33	32.774	37.32	62.29
15 8 35	32.788	37.46	62.43

From South limb — (Satellite following).

			♃β
10 34 8	26.775	22.08	— 1.37
10 35 8	26.802	21.81	1.64
10 35 44	26.825	21.59	1.86
10 36 28	26.791	21.92	— 1.53

From North limb.

10 37 38	31.580	25.50	— 2.05
10 39 31	31.565	25.26	1.84
10 39 43	31.560	25.30	1.85
10 40 33	31.530	25.00	— 1.55

Oct. 21. Up to 10 o'clock, very high wind, shaking telescope. After this, perfectly steady.

October 23.

From South limb — (Satellite following).

			♃β
7 29 2	26.380	26.06	+ 2.63
7 30 17	26.388	25.98	2.55
7 31 17	26.365	26.21	+ 2.78

From North limb.

7 32 17	31.108	20.75	+ 2.68
7 33 7	31.160	21.27	2.16
7 33 47	31.178	21.45	+ 1.98

From South limb.

10 7 21	26.767	22.21	— 1.19
10 9 29	26.791	22.00	1.43
10 10 13	26.817	21.71	1.69
10 10 53	26.830	21.62	— 1.81

From North limb.

10 11 52	31.495	24.58	— 1.15
10 12 54	31.534	24.96	1.53
10 13 42	31.551	25.13	1.70
10 14 42	31.549	25.11	— 1.68

From North limb.

13 48 25	31.577	25.40	— 1.97
13 49 40	31.565	25.28	1.85
13 50 28	31.575	25.39	— 1.95

From South limb.

13 51 36	26.815	21.76	— 1.67
13 52 35	26.798	21.93	1.50
13 53 30	26.806	21.85	— 1.58

Satellite following.

		From E. limb	From center
7 38 21	26.473	25.14	50.04
7 40 7	26.418	25.69	50.59
7 41 37	26.427	25.60	50.50
7 42 31	26.263	27.23	52.13
7 43 45	26.180	28.05	52.95

Satellite following. — *cont.*

		From E. limb	From center
h m s	r	"	"
7 45 15	26.189	27.96	52.86
7 46 54	26.151	28.34	53.24
7 48 45	26.120	28.65	53.55
7 49 59	26.041	29.43	54.33
7 50 57	26.019	29.65	54.55
7 57 24	25.810	31.72	56.62
7 59 31	25.825	31.56	56.46
8 0 42	25.738	32.43	57.33
8 1 31	25.726	32.55	57.45
8 2 27	25.699	32.82	57.72
8 6 47	25.661	33.19	58.09
8 8 22	25.656	33.24	58.14
8 10 19	25.600	33.80	58.70
8 12 1	25.545	34.34	59.24
8 19 10	25.513	34.65	59.55
8 21 12	25.400	35.77	60.67
8 21 57	25.361	36.15	61.05
8 23 12	25.356	36.20	61.10
8 24 51	25.381	35.95	60.85
8 26 17	25.248	37.27	62.17
8 27 32	25.326	36.50	61.40
8 28 30	25.308	36.68	61.58
8 30 29	25.280	36.95	61.85
8 31 7	25.203	37.72	62.62
8 35 17	25.190	37.85	62.75
8 37 52	25.201	37.74	62.64
8 39 0	25.251	37.24	62.14
8 39 57	25.221	37.54	62.44
8 40 42	25.099	38.75	63.65
8 41 52	25.191	37.84	62.74
8 43 5	25.140	38.34	63.24
8 44 31	25.210	37.65	62.55
8 46 17	25.173	38.01	62.91
8 47 54	25.129	38.45	63.35
8 49 21	25.169	38.05	62.95
8 51 5	25.208	37.67	62.57
8 52 3	25.216	37.59	62.49
8 53 5	25.104	38.70	63.60
8 54 1	25.181	37.93	62.83
8 55 17	25.239	37.36	62.26
8 56 10	25.106	38.68	63.58
8 56 53	25.240	37.35	62.25
8 57 37	25.220	37.55	62.45
8 58 27	25.198	37.77	62.67
8 59 57	25.230	37.45	62.35
9 1 9	25.330	36.46	61.36
9 2 20	25.231	37.44	62.34
9 3 50	25.284	36.91	61.81
9 6 37	25.258	37.17	62.07
9 7 47	25.220	37.55	62.45
9 9 41	25.267	37.08	61.98
9 11 2	25.254	37.21	62.11
9 12 38	25.285	36.90	61.80
9 13 57	25.243	37.32	62.32
9 15 25	25.361	36.12	61.02
9 16 52	25.353	36.23	61.13
9 18 42	25.382	35.95	60.85
9 19 52	25.338	36.39	61.29
9 20 53	25.464	35.16	60.06
9 21 50	25.437	35.41	60.31
9 24 35	25.420	35.58	60.48
9 26 1	25.511	34.68	59.58

October 23.

Satellite following. — *cont.*

h m s	r	From E. limb	From center
9 27 43	25.532	34.46	59.36
9 28 45	25.580	33.99	58.89
9 29 54	25.569	34.10	59.00
9 32 22	25.604	33.78	58.68
9 40 19	25.744	32.37	57.27
9 41 54	25.830	31.52	56.42
9 44 44	25.903	30.79	55.69
9 56 7	26.207	27.79	52.69
9 57 17	26.273	27.13	52.03
9 58 40	26.264	27.22	52.12
10 0 39	26.407	25.80	50.70
10 2 47	26.382	26.05	50.95
10 3 52	26.396	25.91	50.81
10 32 17	27.647	13.52	38.42
10 33 59	27.715	12.85	37.75
10 35 16	27.715	12.85	37.75
10 36 17	27.810	11.90	36.80

Satellite preceding.

		From W. limb	From center
13 58 40	32.244	31.94	56.84
14 0 20	32.364	33.18	58.08
14 1 32	32.240	31.66	56.56
14 2 30	32.367	33.21	58.11
14 3 33	32.284	32.39	57.29
14 4 40	32.265	32.20	57.10
14 5 35	32.345	32.90	57.80
14 7 20	32.330	32.85	57.75
14 9 10	32.395	33.49	58.39
14 10 58	32.564	35.13	60.03
14 15 35	32.494	34.47	59.37
14 17 0	32.579	35.32	60.22
14 18 2	32.495	34.48	59.38
14 19 8	32.629	35.81	60.71
14 20 10	32.675	36.26	61.16
14 21 15	32.552	35.04	59.95
14 22 30	32.585	35.37	60.27
14 23 13	32.684	36.35	61.25
14 24 13	32.785	37.35	62.25
14 25 15	32.659	36.10	61.00
14 27 32	32.661	36.12	61.02
14 28 23	32.603	35.55	60.45
14 30 0	32.661	36.12	61.02
14 31 2	32.718	36.69	61.59
14 32 15	32.729	36.80	61.70
14 36 7	32.729	36.80	61.70
14 37 35	32.639	35.90	60.80
14 38 35	32.775	37.25	62.15
14 39 37	32.803	37.52	62.42
14 40 54	32.804	37.51	62.41
14 43 13	32.720	36.71	61.61
14 44 2	32.743	36.93	61.83
14 44 57	32.699	36.50	61.40
14 46 1	32.745	36.95	61.85
14 46 57	32.770	37.20	62.10
14 48 0	32.778	37.28	62.18
14 49 10	32.815	37.65	62.55
14 50 55	32.824	37.74	62.64
14 51 50	32.794	37.44	62.34
14 52 50	32.632	35.84	60.74
14 55 20	32.710	36.61	61.51

Satellite preceding. — *cont.*

		From W. limb	From center
14 56 30	32.709	36.60	61.50
14 57 25	32.820	37.70	62.60
14 58 15	32.858	38.08	62.98
14 59 55	32.699	36.50	61.40
15 0 38	32.865	37.85	62.75
15 2 0	32.654	36.05	60.95
15 3 28	32.715	36.66	61.56
15 4 33	32.709	36.60	61.50
15 6 7	32.705	36.56	61.46
15 7 55	32.661	36.12	61.02
15 9 55	32.564	35.16	60.06
15 12 0	32.720	36.71	61.61
15 14 5	32.672	36.23	61.13
15 16 25	32.610	35.62	60.52
15 18 20	32.568	35.20	60.10
15 20 20	32.473	34.26	59.16

Oct. 23. No wind. Seeing first-class.

October 28.

Satellite following.

		From E. limb	From center
7 51 35	25.464	35.12	60.06
7 52 58	25.454	35.25	60.19
7 54 58	25.477	35.19	60.13
7 55 37	25.394	35.82	60.76
7 56 32	25.420	35.56	60.50
8 1 2	25.279	36.95	61.89
8 2 22	25.185	37.89	62.83
8 3 27	25.288	36.86	61.80
8 4 30	25.293	36.82	61.76
8 5 29	25.330	36.45	61.39
8 6 59	25.240	37.34	62.28
8 8 15	25.283	36.91	61.85
8 9 18	25.218	37.56	62.50
8 10 45	25.203	37.71	62.65
8 13 3	25.239	37.35	62.29
8 14 34	25.217	37.57	62.51
8 15 59	25.181	37.93	62.87
8 17 30	25.257	37.17	62.11
8 18 34	25.237	37.37	62.31
8 19 55	25.231	37.43	62.37
8 20 59	25.186	37.88	62.82
8 23 11	[illegible]	37.45	[illegible]
8 24 46	25.151	38.22	63.16
8 25 30	25.165	38.08	63.02
8 26 36	25.231	37.43	62.37
8 28 17	25.208	37.66	62.60
8 30 8	25.230	37.44	[illegible]
8 31 30	25.235	[illegible]	[illegible]
8 33 31	25.240	37.25	[illegible]
8 34 28	25.267	[illegible]	[illegible]
8 36 5	[illegible]	37.61	[illegible]
8 37 17	[illegible]	[illegible]	[illegible]
8 39 6	[illegible]	[illegible]	[illegible]
8 40 7	[illegible]	[illegible]	[illegible]
8 42 15	[illegible]	[illegible]	[illegible]
8 44 10	[illegible]	[illegible]	[illegible]
8 47 40	[illegible]	[illegible]	[illegible]
8 50 13	[illegible]	[illegible]	[illegible]

Satellite preceding.

h m s	r	From W. limb	From center
		″	″
14 13 3	32.795	37.48	62.42
14 14 22	32.711	36.64	61.58
14 15 0	32.779	37.31	62.25
14 15 48	32.710	36.63	61.57
14 16 38	32.722	36.75	61.69
14 18 20	32.752	37.04	61.98
14 19 28	32.759	37.11	62.05
14 20 23	32.799	37.51	62.45
14 21 13	32.773	37.25	62.19
14 22 28	32.789	37.41	62.35
14 23 15	32.773	37.25	62.19
14 24 48	32.728	36.81	61.75
14 25 13	32.761	37.13	62.07
14 27 48	32.793	37.45	62.39
14 28 48	32.803	37.55	62.49
14 29 33	32.775	37.27	62.21
14 30 28	32.764	37.16	62.10
14 31 30	32.762	37.14	62.08
14 33 8	32.796	37.48	62.42
14 33 56	32.712	36.94	61.88
14 35 43	32.780	37.32	62.26
14 36 28	32.667	36.20	61.14
14 37 23	32.762	37.14	62.08
14 38 14	32.768	37.21	62.15
14 39 28	32.664	36.17	61.11
14 40 33	32.732	36.84	61.78
14 41 13	32.665	36.18	61.12
14 42 10	32.715	36.68	61.62
14 43 33	32.674	36.27	61.21
14 44 18	32.583	35.37	60.31

From South limb—(Satellite following). ♃β

9 23 3	26.725	22.64	— 0.69
9 25 40	26.757	22.32	— 1.01

Satellite lost here in fog.

From North limb.

9 45 45	31.592	25.56	— 2.23
9 46 32	31.583	25.47	2.14
9 47 14	31.536	25.00	— 1.67

From South limb.

9 49 0	26.859	21.34	— 2.02
9 50 20	26.710	22.49	0.81
9 51 18	26.829	21.61	— 1.72

Oct 28. Frequent fogging throughout the night.

November 4.

Satellite following.

		From E. limb	From center
6 55 40	26.155	31.25	55.84
6 57 15	26.140	31.40	55.99
6 58 35	26.079	32.00	56.59
6 59 55	26.012	32.67	57.26
7 2 45	26.015	32.64	57.23
7 13 50	25.785	34.91	59.50
7 15 27	25.784	34.92	59.51
7 16 17	25.770	35.06	59.65
7 18 38	25.781	34.95	59.54
7 20 12	25.646	36.29	60.88
7 21 10	25.700	35.76	60.35
7 22 37	25.680	35.95	60.54
7 25 30	25.685	35.90	60.49
7 30 0	25.567	37.07	61.66
7 31 53	25.535	37.39	61.98

Satellite following.—*cont.*

h m s	r	From E. limb	From center
		″	″
7 33 7	25.583	36.91	61.50
7 35 35	25.546	37.28	61.87
7 36 35	25.573	37.01	61.60
7 38 0	25.530	37.44	62.03
7 40 20	25.521	37.53	62.12
7 42 17	25.602	36.73	61.32
7 43 14	25.520	37.54	62.13
7 44 17	25.582	36.92	61.51
7 46 27	25.590	36.84	61.43
7 48 35	25.595	36.80	61.39
7 49 40	25.604	36.71	61.30
7 50 50	25.539	37.35	61.94
7 52 20	25.570	37.04	61.63
7 54 16	25.559	37.15	61.74
7 56 5	25.583	36.91	61.50
7 58 5	25.672	37.02	61.64
8 0 22	25.621	36.54	61.13
8 2 17	25.666	36.09	60.68
8 4 21	25.715	35.61	60.20
8 8 55	25.746	35.21	59.80
8 10 20	25.750	35.17	59.76
8 12 0	25.738	35.38	59.97
8 13 17	25.782	34.94	59.53
8 14 55	25.812	34.65	59.24
8 26 41	25.912	33.66	58.25
8 28 8	26.002	32.77	57.36

Satellite preceding.

		From W. limb	From center
13 3 15	32.639	32.95	57.54
13 4 58	32.631	32.87	57.46
13 6 10	32.699	33.55	58.14
13 7 31	32.696	33.52	58.11
13 8 46	32.775	34.30	58.89
13 11 3	32.795	34.50	59.09
13 14 30	32.820	34.75	59.34
13 15 28	32.838	34.92	59.51
13 17 28	32.912	35.66	60.25
13 22 58	32.840	34.94	59.53
13 24 8	32.954	36.07	60.66
13 25 20	32.953	36.06	60.65
13 26 23	33.011	36.64	61.23
13 28 13	32.985	36.38	60.97
13 32 13	33.059	37.11	61.70
13 33 50	33.016	36.69	61.28
13 34 53	33.011	36.64	61.23
13 38 8	33.044	36.96	61.55
13 41 27	33.054	37.06	61.65
13 44 8	33.048	37.00	61.59
13 48 15	33.070	37.22	61.81
13 50 3	33.029	36.82	61.41
13 51 43	33.030	36.82	61.41
13 53 45	33.068	37.20	61.79
13 56 18	33.058	37.10	61.69
14 1 53	32.958	36.11	60.70
14 3 58	32.939	35.92	60.51
14 6 35	32.920	35.74	60.33

From South limb — (Satellite following).

			♃β
9 11 55	27.079	22.10	— 0.83
9 13 0	27.083	22.06	0.87
9 14 0	27.175	21.15	1.78
9 14 55	27.138	21.52	— 1.41

From North limb — Satellite following.

h m s	'		♃
9 16 27	31.836	25.00	— 2.07
9 17 25	31.802	24.67	1.74
9 18 5	31.849	25.13	2.20
9 18 55	31.849	25.13	— 2.20

Nov. 4. Night fair: not much wind.

November 6.

Satellite following.

		From E. limb	From center
6 44 54	26.134	31.44	56.01
6 46 25	26.104	31.74	56.31
6 47 35	26.119	31.59	56.16
7 5 28	25.655	36.18	60.75
7 7 40	25.777	34.97	59.54
7 8 45	25.620	36.53	61.10
7 10 47	25.738	35.36	59.93
7 13 30	25.720	35.54	60.11
7 15 3	25.667	36.06	60.63
7 16 55	25.713	35.61	60.18
7 21 15	25.594	36.79	61.36
7 25 12	25.574	36.98	61.55
7 29 45	25.575	36.97	61.54
7 32 35	25.509	37.63	62.20
7 34 50	25.580	36.92	61.49
7 36 5	25.546	37.26	61.83
7 37 25	25.589	36.83	61.40
7 40 15	25.594	36.79	61.36
7 44 50	25.626	36.47	61.04
7 45 5	25.621	36.52	61.09
7 47 10	25.577	36.95	61.52
7 49 5	25.599	36.74	61.31
7 52 25	25.651	36.22	60.79
7 53 50	25.690	35.83	60.40
7 55 37	25.705	35.69	60.26
8 1 40	25.761	35.10	59.67
8 2 27	25.830	34.45	59.02
8 3 32	25.780	34.94	59.51
8 26 15	26.150	31.28	55.85
8 27 17	26.230	30.49	55.06
8 28 35	26.327	29.53	54.10

Nov. 6. Wind shaking telescope.

November 11.

Satellite following.

		From E. limb	From center
6 33 25	25.932	33.43	57.69
6 34 40	25.818	34.27	58.53
6 36 3	25.820	34.55	58.81
6 37 0	25.910	33.66	57.92
6 38 15	25.870	34.05	58.31
6 39 35	25.823	34.52	58.78
6 40 25	25.795	34.80	59.06
6 41 30	25.813	34.62	58.88
6 45 0	25.731	35.43	59.69
6 46 37	25.740	35.34	59.60
6 48 0	25.747	35.27	59.53
6 49 55	25.714	35.60	59.86
6 51 25	25.743	35.31	59.57
6 52 40	25.660	36.13	60.39

Satellite following — [illegible]

		From E. limb	From center
6 53 15	25.760	37.12	[illegible]
6 54 15	25.698	35.76	[illegible]
6 56 0	25.576	36.66	61.22
6 57 15	25.680	[illegible]	60.14
6 59 30	25.590	36.82	[illegible]
7 1 10	25.651	36.42	[illegible]
7 4 25	25.573	[illegible]	[illegible]
7 5 25	25.645	36.28	[illegible]
7 7 25	25.618	36.55	[illegible]
7 8 35	25.680	[illegible]	[illegible]
7 9 45	25.630	[illegible]	[illegible]
7 11 25	25.602	36.71	[illegible]
7 12 50	25.640	36.33	[illegible]
7 13 55	25.628	36.15	60.71
7 14 45	25.613	36.00	60.56
7 21 0	25.600	36.13	[illegible]
7 22 27	25.720	35.54	[illegible]
7 23 18	25.644	36.20	[illegible]
7 26 50	25.713	35.31	[illegible]
7 27 10	25.825	34.50	58.76
7 28 35	25.763	35.71	[illegible]
7 30 7	25.755	35.19	[illegible]
7 31 30	25.743	35.31	[illegible]
7 33 50	25.810	34.65	[illegible]
7 35 52	25.884	[illegible]	58.17
7 37 0	25.874	34.01	58.27
7 37 55	25.845	34.30	[illegible]
7 40 30	25.880	33.95	58.21
7 42 0	25.965	33.11	[illegible]
7 43 15	25.900	33.76	[illegible]
7 44 35	25.909	33.67	[illegible]
7 47 7	26.041	32.36	[illegible]
8 1 50	26.374	29.06	[illegible]
8 6 0	26.380	28.91	[illegible]

From North limb — Satellite following.

			♃
8 11 5	26.922	23.64	[illegible]
8 12 15	26.932	23.54	[illegible]
8 13 15	26.943	23.43	[illegible]
8 15 55	26.895	[illegible]	[illegible]

From South limb.

8 17 15	31.544	[illegible]	[illegible]
8 18 20	31.441	[illegible]	[illegible]
8 19 2	31.522	[illegible]	[illegible]
8 19 55	31.570	[illegible]	[illegible]

Satellite preceding.

		From W. limb	From center
12 51 0	32.850	[illegible]	[illegible]
12 52 15	[illegible]	[illegible]	[illegible]
12 53 50	[illegible]	[illegible]	[illegible]
12 55 40	32.940	[illegible]	[illegible]
12 56 40	[illegible]	[illegible]	[illegible]
12 57 12	[illegible]	[illegible]	[illegible]
12 58 12	[illegible]	[illegible]	[illegible]
13 2 52	[illegible]	[illegible]	[illegible]
13 [illegible] 15	[illegible]	[illegible]	[illegible]
13 7 2[illegible]	[illegible]	[illegible]	[illegible]
13 8 50	[illegible]	[illegible]	[illegible]
13 10 10	[illegible]	[illegible]	[illegible]
13 11 55	[illegible]	[illegible]	[illegible]
13 14 27	[illegible]	[illegible]	[illegible]

Satellite preceding — *cont.*

		From W. limb	From center
h m s	r	″	″
13 16 10	32.957	36.12	60.38
13 19 22	32.950	36.05	60.31
13 21 0	32.892	35.18	59.74
13 23 42	32.887	35.43	59.69

Nov 11. Not much wind.

November 13.

Satellite following.

		From E. limb	From center
6 57 13	25.685	35.79	59.93
6 59 23	25.671	35.92	60.06
7 1 0	25.645	36.18	60.32
7 2 35	25.675	35.88	60.02
7 3 27	25.603	36.60	60.74
7 5 0	25.604	36.62	60.76
7 6 35	25.700	35.64	59.78
7 7 55	25.620	36.43	60.57
7 9 24	25.712	35.52	59.66
7 12 3	25.721	35.43	59.57
7 13 18	25.707	35.57	59.71
7 15 49	25.801	34.64	58.78
7 17 30	25.728	35.36	59.50
7 20 55	25.761	35.00	59.14
7 24 0	25.826	34.39	58.53
7 26 27	25 806	34.59	58.73
7 32 37	25.961	33.05	57.19
7 34 0	26.007	32.60	56.74
7 35 5	25.982	32.85	56.99
7 37 50	26.000	32.67	56.81
7 40 0	26.098	31.70	55.84
7 46 40	26.202	30.67	54.84

Nov. 13. High wind from north. Telescope vibrating some.

November 18.

Satellite preceding.

		From W. limb	From center
11 30 3	32.196	28.77	52.72
11 32 23	32.161	28.42	52.37
11 33 40	32.175	28.56	52.51
11 35 34	32.254	29.34	53.29
11 36 38	32.275	29.55	53.50
11 39 8	32.389	30.68	54.63
11 42 4	32.405	30.83	54.78
11 43 28	32.365	30.44	54.39
11 54 38	32.609	32.86	56.84
11 56 28	32.674	33.47	57.42
11 58 43	32.770	34.45	58.40
12 3 58	32.795	34.70	58.65
12 5 15	32.744	34.19	58.14
12 6 20	32.770	34.45	58.40
12 7 42	32.759	34.34	58.29
12 9 25	32.796	34.71	58.66
12 10 15	32.813	34.87	58.82
12 12 30	32 850	35.24	59.19
12 21 20	32.872	35.46	59.41
12 22 33	32.902	35.76	59.71
12 23 53	32.943	36.16	60.11
12 26 3	32.885	35.59	59 54
12 27 28	32.850	35.24	59.19
12 29 23	32.964	36.34	60.29

Satellite preceding. — *cont.*

		From W. limb	From center
h m s	r	″	″
12 31 10	32.864	35.38	59.33
12 34 28	32.894	35 68	59.63
12 36 43	32.870	35.44	59.39
12 37 51	32.857	35.31	59.26
12 39 13	32.851	35.25	59.20
12 44 33	32.837	35.11	59.06

Nov. 18. Observations interrupted by clouds, but measures good.

November 20.

Satellite following.

		From E. limb	From center
6 6 30	25.645	36.10	59.80
6 8 25	25.670	35.85	59.55
6 10 0	25.640	36.15	59.85
6 12 25	25.653	36.02	59.72
6 13 10	25.640	36.15	59.85
6 14 10	25.690	35.66	59.36
6 15 55	25.745	35.11	58.84
6 18 17	25.651	36.04	59.74
6 21 40	25.714	35.42	59.12
6 26 45	25.656	35.99	59.69
6 28 0	25.710	35.46	59.16
6 28 40	25.708	35.45	59.18
6 36 15	25.747	35.09	58.79
6 37 10	25.785	34.72	58.42
6 39 17	25.754	35.02	58.72
6 42 30	25.750	35.06	58.76
6 44 10	25.835	34.22	57.92
6 45 30	25.810	34.47	58.17
6 46 10	25.885	33.73	57.43
6 47 15	25.870	33.87	57.57
6 49 20	25.902	33.56	57.26
7 21 24	26.515	27.49	51.19
7 22 42	26.555	27.09	50.79
7 23 55	26.560	27.04	50.74
7 24 57	26.637	26.28	49.98
7 25 49	26.739	25.27	48.97
8 4 5	28.102	11.77	35.47
8 7 9	28 286	10.05	33.75

From South limb — Satellite following).

			♃ 3
7 31 13	27.171	20.99	— 1.37
7 32 22	27.242	20.29	2.07
7 33 7	27.279	19.92	2.44
7 34 7	27.220	20.51	— 1.85

From North limb.

7 35 15	31.794	24.75	— 2.39
7 32 32	31.845	25.29	2.93
7 37 30	31.790	24.74	2.38
7 38 40	31.744	24.29	— 1.93

From North limb — (Satellite following).

7 56 0	31.817	25.01	— 2.65
7 57 0	31.795	24.79	— 2.43

From South limb.

7 58 30	27 233	20 38	— 1.98
7 59 40	27.314	19.58	— 2.78

Nov. 20. Up to 7h wind shaking telescope and seeing' poor. After that steady, and observations good.

I have carefully plotted the measures near the elongation of the satellite, and by the aid of a curve drawn through these have secured the following elongation distances. For comparison they are also reduced to distance 5.20.

It will be seen that the distance at west elongation is certainly less than that of the eastern.

No correction has been applied for phase. The measures do not extend much on each side of opposition; the phase would not have a sensible effect.

ELONGATION DISTANCES OF THE FIFTH SATELLITE DEDUCED GRAPHICALLY FROM THE MEASURES AT ELONGATIONS.

1892	East Elongation Appt.	East Elongation 5.20	West Elongation Appt	West Elongation 5.20
d	″	″		
Sept. 10	61.01	17.99	. .	. .
11	61.20	18.01	. .	. .
12	61.55	18.17	. .	. .
14	61.60	18.03	. .	. .
23	62.18	17.82	. .	. .
27	63.22	18.39	. .	. .
Oct. 7	63.43	18.25	. .	. .
9	63.39	18.19	62.25	17.33
17	. .	. .	62.00	17.22
23	62.90	18.07	61.95	17.34
28	62.62	18.17	62.12	17.79
Nov. 4	61.73	18.01	61.70	17.99
6	61.64	18.22	. .	. .
11	60.80	18.05	60.45	17.77
13	60.40	17.87	. .	. .
18	. .	. .	59.72	17.91
		18.089		17.621
		±0.064		±0.176

The probable errors of a single determination are ±0″.23 and ±0″.17 respectively.

These respectively correspond to the following distances:

East elongation 112500 ± 143 miles.
West elongation 111110 ± 412 miles.

The times of elongation have been obtained graphically by plotting the measures. This method is, however, not so accurate as computing the elongation-time from measures of distances on each side of elongation from the formula,

$$T = t \pm 0.502 \cos^{-1}\frac{\delta}{\Delta}$$

where t = the time of observation, δ the measured distance, and Δ the apparent elongation-distance; the motion of the satellite in one minute being 0″.502.

In the following table are given the elongations. The letter *G* shows the resulting time was derived graphically, while *C* indicates that it was derived from measures.

	East	West
d	h m	
Sept. 10	12 19 *G*	
10	12 17.5 *C*	
12	12 33 *G*	
14	12 23 *G*	
23	11 33 *G*	
27	11 7 *G*	
Oct. 7	10 19 *G*	
9	. .	[illegible] *G*
17	. .	[illegible] 7 *G*
21	[illegible] 2.8 *C*	
23	8 19 *G*	[illegible] 8 *G*
28	8 21 *G*	[illegible] *G*
28	8 21.2 *C*	
Nov. 4	7 43 *G*	[illegible] *G*
6	7 34 *G*	
11	7 9 *G*	[illegible] *G*
11	7 7.1 *C*	
18	. .	[illegible] *G*
20	6 19.8 *C*	

The graphical determination s[illegible] little value.

I have carefully gone over the [illegible] odic time of the satellite, and adopting [illegible] deduced the following values for the p[illegible] using the computed values of the elong[illegible] recting for aberration and parallax:

Sept. 10 – Oct. 21 $P =$ 11 57 [illegible] 72
Sept. 10 – Oct. 28 $P =$ 11 57 [illegible]
Sept. 10 – Nov. 20 $P =$ 11 57 22.7[illegible]

Applying weights proportional to the [illegible] vals, the mean of these gives

Period = 11 57 23.[illegible]

The elongation time of Nov. 20 w[illegible] measures on only one side of elongation.

The hourly motion of the sa[illegible] velocity in its orbit about 16 [illegible] some twelve times as rapid as the motion [illegible] ner satellite of *Mars*. The horizontal eq[illegible] the new satellite is 21 51 [illegible] The dista[illegible] of *Jupiter* is about 67000 miles.

The satellite seems equally bright [illegible] western elongation.

No amount of magnifying power has s[illegible] as a stellar point.

Its shadow can not be seen in trans[illegible]

I have not succeeded in getting [illegible] satellite since November 20, until [illegible] 1893, when it was again observed [illegible] tion. It was excessively faint, [illegible] good, the air being perfectly steady, [illegible] class. It was only possible to observe [illegible] the passage of [illegible] across [illegible] dome not being [illegible] It was [illegible]

[illegible]

ADDENDUM.

1893 *January* 5.

Satellite preceding

		From prec. limb	From center
h m s	′	″	″
8 23 53	3.269	32.15	52.72
8 27 43	3.334	32.80	53.37
8 36 13	3.216	31.63	52.20
8 40 38	3.062	30.10	50.67
8 41 58	3.128	30.76	51.33
8 43 18	3.061	30.09	50.66
8 45 3	3.070	30.18	50.75
8 46 33	3.042	29.90	50.47
8 48 13	3.069	30.17	50.74
8 50 33	3.054	30.02	50.59
8 52 23	2.991	29.40	49.97
8 53 48	3.003	29.52	50.09
8 55 18	2.968	29.17	49.74
8 56 18	2.920	28.70	49.27

Computing the elongation-time from the last three measures I find

West elongation 1893 Jan. $5^d\ 8^h\ 24^m.7$ S.P.T.
$= $ Jan. $5^d\ 16^h\ 24^m.7$ G.M.T.

From MARTH's ephemeris in *The Observatory* for December, 1892, the west elongation should have been at $16^h\ 23^m.6$ G.M.T., which shows the satellite is running close to the ephemeris.

1893 *January* 8.

Satellite preceding.

		From prec. limb	From center	
h m s	′	″	″	
7 23 21	2.740	26.79	47.22	
7 30 29	2.970	29.07	49.50	
7 31 51	2.878	28.16	48.59	good
7 39 19	2.993	29.33	49.73	
7 42 30	2.870	28.08	48.51	
7 44 16	3.071	30.07	50.50	good
7 46 50	2.855	27.93	48.36	
7 47 10	3.119	30.55	50.98	

Satellite extremely faint and difficult. Coincidence of threads $0^r.034$.

Computing the elongation-time from the first four of these we have

West elongation 1893 Jan. $8^d\ 16^h\ 6^m.4$ G.M.T.

According to MARTH's ephemeris this occurred at $16^h\ 8^m.4$.

These are doubtless the last observations that will be made here of the satellite during this opposition of *Jupiter*.

ON THE PERIOD OF 5950 W *HERCULIS*,

BY HENRY M. PARKHURST.

The elements of 5950 W *Herculis* in CHANDLER's table, *A.J.* 179–80, are now, from the variation of the period, more than four months in error. The reduction of my observations, together with those of Mr. EADIE, from 1884 to 1892, including also earlier maxima deduced by Dr. CHANDLER, and kindly furnished me, has enabled me to obtain approximate elements including that variation. The results are shown in the following table.

E	C	C—O	C′—O
—29	1857 April 17	+ 5	— 4
0	1879 June 7	+39	+15
2	1881 Jan. 26	0	—17
5	1883 May 25	— 9	0
6	1884 Mar. 3	—12	+ 5
8	1885 Sept. 27	—25	— 1
9	1886 July 1	—22	0
12	1888 Sept. 27	— 1	— 1
16	1891 Sept. 27	+21	0
17	1892 July 7	+20	— 2
18	1893	(May 3)	(Apr. 16)

The first column gives the number of periods from the epoch; the second column the observed maxima; the third column gives the comparison with a uniform period of 280 days, including prediction for the next maximum; and the fourth column gives the comparison with the following formula:

$$\text{Max.} = 1879 \text{ June } 22 + 280^d.0 + 24^d(\sin 22°.5\,E + 270°)$$

The epoch —29 was derived from DM. estimates; the next two from DUNÉR's observations; the next two from CHANDLER's observations; the remaining maxima were derived by smoothing the curves, and employing my parabolic method, from the several series of observations made by EADIE and myself.

Brooklyn, 1893 *Jan.* 7.

OBSERVATIONS OF COMET *g* 1892 (BROOKS),

MADE AT THE CINCINNATI OBSERVATORY.

BY J. G. PORTER.

1892–3 Cincinnati M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Dec. 28 15 16 29	1	8 , 8	+3 2.73	+0 3.9	15 36 3.70	+55 52 31.9	*n*9.911	0.444
15 16 29	2	8 , 8	+2 10.33	+0 23.0	15 36 3.87	+55 52 28.9	*n*9.911	0.444
Jan. 9 16 23 49	3	9 , 9	—0 21.22	+0 30.3	20 49 38	+63 15	*n*9.816	0.842
10 7 51 7	4	8 , 8	+0 20.74	—3 59.6	21 1 0.60	+62 25 31.6	9.995	0.453
7 51 7	5	4 , 4	—0 54.00	—2 18.7	21 4 0.09	+62 25 34.8	9.995	0.453

Mean Places of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	1892.0 h m s	s	1892.0 ° ′ ″	″	
1	15 33 1.09	−0.12	+55 52 55.7	−27.7	Krueger A.G.Z. 8423
2	15 33 23.66	−0.12	+55 52 33.6	−27.7	Krueger A.G.Z. 8428
	1893.0		1893.0		
3	20 50 5	−3.56	+63 14	−1.3	Undetermined
4	21 3 43.32	−3.46	+62 29 31.7	−0.5	Krueger A.G.Z. 11911
5	21 4 57.55	−3.46	+62 27 53.9	−0.4	Krueger A.G.Z. 11930

The following elements represent the observations up to Dec. 28 very closely. The deviation of the position for Jan. 10 is (O−C). −7s, +0′.2.

T = 1893 Jan. 6.5178 Greenwich M.T.

$$\left.\begin{aligned} \Omega &= 185^\circ\ 39'.4 \\ \omega &= 85\ 14.5 \\ i &= 143\ 52.0 \end{aligned}\right\}1893.0$$

$\log q$ = 0.07734

EPHEMERIS OF COMET *g* 1892, BY PHILLIPS ISHAM.

Gr. M.T.	App. α	App. δ	log r	log Δ
1893	h m s	° ′		
Jan. 22.5	23 17 16	+44 58.3	0.0867	0.0023
23.5	23 22 24	43 45.7		
24.5	23 27 6	+42 36.4	0.0894	0.0251
Jan. 25.5	23 31 27	+41 30.6		
26.5	23 35 26	40 27.4	0.0918	0.0474
27.5	23 39 9	39 27.4		
28.5	23 42 37	38 30.1	0.0947	0.0691
29.5	23 45 51	37 35.8		
30.5	23 48 53	36 43.8	0.0978	0.0901
31.5	23 51 44	35 54.0		
Feb. 1.5	23 54 26	35 6.7	0.1012	0.1101
2.5	23 56 58	34 21.2		
3.5	23 59 23	33 38.0	0.1047	0.1297
4.5	0 1 41	32 57.0		
5.5	0 3 52	32 18.1	0.1084	0.1484
6.5	0 5 56	+31 40.6		

FILAR-MICROMETER OBSERVATIONS OF COMET *g* 1892.

MADE AT VASSAR COLLEGE OBSERVATORY

BY MARY W. WHITNEY.

1892 Poughkeepsie M.T.	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ	log pΔ
h m s			m s	′ ″	h m s	° ′ ″		
Dec. 17 17 21 0	1	5	−4 3.16	−0 35.2	11 1 16.61	+35 34 33.3	[illegible]	[illegible]
20 17 9 2	2	4	+3 48.20	0 12.3	11 17 24.16	+40 23 25.5	[illegible]	[illegible]

Mean Places of Comparison-Stars for 1892.0.

*	α	Reduction	δ	Reduction	Authority
	h m s			″	
1	11 5 18.46	+1.31	+35 35 34.6	−26.1	Bonn VI, 35.2[illegible]
2	11 13 34.70	+1.26	+40 24 35.8	28.0	W.B. XIV, 260

FILAR-MICROMETER OBSERVATIONS OF COMETS *g* AND *f* 1892.

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY

BY E. E. BARNARD.

1892-3 Mt. Hamilton M.T.	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ	log pΔ
			COMET *g* 1892 (BROOKS).					
h m s								
Nov. 24 17 23 7	1	6 , 4	−2 49.80	+1 45.7	13 [illegible]	[illegible] 18	[illegible]	[illegible]
			COMET *f* 1892 (HOLMES).					
Jan. 4 7 28 35	6	5 , 4	−0 22.66	−5 33.0	[illegible]	[illegible]	[illegible]	[illegible]

Mean Places of Comparison-Stars, for beginning of the Year.

*	α	Reduction	δ	Reduction	Authority
	h m s				
1	13 6 33.4	+1.27	+15 16.8	[illegible]	DM. [illegible]
6	1 8 2.36	0.81	+33 5[illegible] 33.7	[illegible]	Weisse's Bessel 1.

Nov. 24. Comet observed through thick wet haze. [illegible]

Jan. 4. With low power, comet very large and very faint [illegible] exceedingly faint and difficult fleck of light.

METEORS OF 1892 NOVEMBER 23.

By WILLIAM J. HUSSEY.

The number of meteors counted here, on the night of 1892 Nov. 23, was greater than that reported by your correspondents in *Astronomical Journal*, no. 283.

They were watched here from dark till midnight. I counted them at various times during the night, and once continuously for upwards of an hour. I found that a single observer could see on the average from 50 to 60 in five minutes.

They did not come at a strictly constant rate, though nearly so, as the excess of one moment was balanced by the defect of the next. It was not unusual to see three or four, or even five, radiating simultaneously.

The radiant was determined by means of a considerable number of bright meteors and found to be very approximately $\alpha = 1^h\,39^m$, $\delta = +12°$.

In determining it two particularly bright ones were used; one of which passed eastward near ; and the other southwestward between ν and τ *Andromedae*.

Only the usual sporadic meteors were seen the next night. It was cloudy here on Nov. 27.

Palo Alto, California, 1893 *Jan.* 2.

COMET *f* 1892 (HOLMES).

The *Central Bureau* telegraphs that this comet was found by Dr. PALISA, Jan. 16, to have exhibited another sudden change of brilliancy. It appeared of the eighth magnitude, circular, less than 1′ in diameter, and with strong central condensation.

NEW ASTEROIDS.

Prof. KREUTZ has communicated the discovery of two more, found during the year 1892; one photographed by CHARLOIS at Nice, — the other by WOLF at Heidelberg. Earliest observations are.

U. Dec. 15, $7^h\ 5^m.9$ Nice M.T. $\alpha = 71°\ 53'\ 7''$, $\delta = +12°\ 15'\ 10''$.
Daily motion, — 13′ in α, and 6′ northward. 12^M.
V. Dec. 18, $12^h\ 31^m.8$ Heidelberg M.T. $\alpha = 87°\ 53'$, $\delta = +20°\ 14'$.
Daily motion, — 16′ in α, and 3′ northward. 11^M.

The name *Svea* has been given to the planet found by WOLF on March 21, and *Roberta* to that of STAUS, Sept. 1, (1892 *C*).

NOTICE.

The Library of Columbia College, New York City, has for sale a set of the *Astronomische Nachrichten*, vols. 4–123, inclusive, in perfect condition and mostly well bound. Offers may be sent to Mr. HAROLD JACOBY at the College.

CORRIGENDA.

No. 275, p. 82, col. 2, line 10 *for* $11^h\ 5^m\ 25^s$ *put* $12^h\ 5^m\ 25^s$.
No. 283, p. 149, Comet's app. δ Nov. 10 *for* $+38°\ 10'\ 12''.7$ *put* $+38°\ 10'\ 38''.6$.

CONTENTS.

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ON THE CONSTANT OF ABERRATION.

By S. C. CHANDLER

I.

§1. The problem to be solved in the revision of the various determinations of the aberration-constant, to free them from the effects of the latitude-variation, is as follows. A series of observed apparent zenith-distances having been reduced with an approximate aberration-constant and an assumed constant value of the latitude, it is required to find, from the resulting observed declinations, the true aberration, parallax, mean latitude and declination, and the elements of the variation of latitude according to the law of equation (19). Following is a synopsis of the notation and working formulas uniformly used throughout the succeeding investigations.

(22)
Let φ = actual latitude at the date t.
φ_0 = true mean latitude.
φ'_0 = an assumed value of φ_0.
δ = observed declination at the date t, reduced to a common epoch.
δ_0 = true declination, free from the latitude-variation.
δ'_0 = an assumed value of δ_0.

(23) For brevity, put $T_1 = T'_1 + \frac{\lambda}{\theta}$, $G = G' + \lambda$

so that (19) becomes

(24) $\varphi_0 - \varphi = r_1 \cos(t - T'_1)\theta + r_2 \cos(\odot - G')$

Take an assumed approximate value of T'_1, so that

(25) $T'_1 = T'_0 + \Delta T$, and put $\varsigma = (t - T'_0)\theta$

Further, let

(26)
x = corr. to assumed mean latitude, or $\varphi_0 - \varphi'_0$.
ξ = corr. to assumed declination, or $\delta_0 - \delta'_0$.
$y = -r_1 \sin(\theta\,\Delta T)$, $z = -r_1 \cos(\theta\,\Delta T)$
$\eta = -r_2 \sin G'$, $\zeta = -r_2 \cos G'$
u = corr. to assumed aberration-constant.
π = annual parallax.
$n = \delta'_0 - \delta$, upper culm., or $\delta - \delta'_0$, lower culm.

(27) $p = \sin\varepsilon \cos\delta - \cos\varepsilon \sin\alpha \sin\delta$, $q = \cos\alpha \sin\delta$

the signs of p and q being changed for lower culmination.

Further, take

(28)
$$Y = qu - p\pi + \eta$$
$$Z = pu + q\pi + \zeta$$

No sensible error will arise, with so small [illegible] the parallax, in regarding the earth's orbit as [illegible]

Then we have

$$x \mp \xi + y \sin\varsigma + z \cos\varsigma + Y \sin\odot + Z \cos\odot = n \qquad (29)$$

the upper sign of ξ corresponding to upper [illegible]. Each observation gives an equation of con[illegible] form. The values Y and Z of the resulting sol[illegible] the various stars, being inserted in (28), the s[illegible] latter gives u, π, η and ζ. Then we get

$$r_1^2 = y^2 + z^2 \ , \quad r_2^2 = \eta^2 + \zeta^2$$
$$\tan(\theta\,\Delta T) = \frac{y}{z} \ , \quad \tan G' = \frac{\eta}{\zeta} \qquad (30)$$

and finally T_1 and G from (25) and (23).

In regard to the peculiar arrangement of [illegible] here employed, it is desired to say that, [illegible] method of computing the coefficients of [illegible] tation for the separate observations might [illegible] management of the work would have been [illegible] less convenient. The introduction of the functions Y and Z of [illegible] u, π, η and ζ, is not only a labor-saving device [illegible] tions, but greatly facilitates the discussion of the results.

An examination of the above equations shows at once the conditions under which the observations must be taken to make the solution a determinate one for all the unknowns, and the most convenient mode of conducting the computation.

The corrections to the mean [illegible] x and ξ, can both be found only from observations [illegible] and lower culminations. [illegible] used either singly or in groups, give [illegible] nations of [illegible] at both culminations, [illegible] made very conveniently. Thus, [illegible] servations, or each pair of groups, w[illegible]

[illegible]

we have, from the [illegible] sums [illegible] coefficients of [illegible] π and [illegible] culminations.

$$(32) \qquad x + y \sin\gamma + z \cos\gamma + \eta \sin\odot + \zeta \cos\odot = n_1$$

and from the half-differences,

$$(33) \qquad -\xi + Y \sin\odot + Z \cos\odot = n_2$$

$$(34) \qquad u = \frac{qY + pZ}{p^2 + q^2} \quad , \quad \pi = \frac{qZ - pY}{p^2 + q^2}$$

In this case all the unknowns are determinate, even if but one star be observed, provided the series be long enough to secure a proper difference in the coefficients of the 427-day and the annual terms.

If we have only observations at upper culmination, as in prime-vertical transits, for example, we get, putting $X = x - \xi$,

$$(35) \qquad X + y \sin\gamma + z \cos\gamma + Y \sin\odot + Z \cos\odot = n$$

But here the problem is indeterminate if but one star has been observed; for, with Y and Z found from (35) substituted in (28), we have only two equations to find four unknowns, u, π, η and ζ. To obtain a determinate result in this case we shall have to introduce values of η and ζ found from some other source, and get u and π from

$$(36) \quad u = \frac{q(Y - \eta) + p(Z - \zeta)}{p^2 + q^2} \quad , \quad \pi = \frac{q(Z - \zeta) - p(Y - \eta)}{p^2 + q^2}$$

If several stars have been observed, the solution will be determinate if they are reasonably well distributed in right-ascension. Each star will give a value of Y with its weight w_1, and of Z with its weight w_2. Eliminating π from (28) we find

$$(37) \qquad q\eta + p\zeta + (p^2 + q^2)u = qY + pZ$$

the weight of which is

$$(38) \qquad w_0 = \frac{w_1 w_2}{w_1 p^2 + w_2 q^2}$$

Each star gives an equation of condition of the form of (37): the solution of all, using the weights according to (38), gives the correction to the assumed aberration, u, and also the values of η and ζ. Then, substituting the latter in (36), we get, if desired, the aberration-correction furnished by the several stars, and also their parallaxes.

The above brings to light the uncomfortable fact that all determinations of the aberration and parallax, from series like those on *α Lyrae* (1862–67) with the Washington prime-vertical transit, or on *γ Draconis* (1857–75) with the Greenwich reflex zenith-tube, — not to quote other examples, — must, from the nature of things, be illusory; and that the constants heretofore deduced in those cases are fallacious. We can now, indeed, easily explain the persistency with which negative parallaxes have appeared in some of these instances, and abnormally large positive parallaxes in others. This will be abundantly illustrated in the sequel. Thus is also revealed the source of the extraordinary systematic anomalies in the aberrations indicated by the different stars in Nyrén's determination of 1880–82. It may not be out of place to remark with regard to the latter that the time chosen was, accidentally, favorable to the smallest possible display of such anomalies, since at that epoch the 427-day and the annual terms nearly nullified each other. If it had been undertaken a couple of years earlier or later, when these terms operated in the same sense, the disturbances would have been multiplied. If that research had been continued it would undoubtedly have precipitated the discovery of the existence and the law of the variation of latitude.

Besides the series suitable for the derivation of the aberration, there are a large number of others from which it is proposed to deduce the elements of the latitude-variation alone, homogeneously by the application of the above formulas. The collation and discussion of all will then, it is hoped, enable us to find the definitive values of the co-efficients, and the law of their variations. The computations in this direction so far made confirm a conviction forced on my attention last summer by the solutions from which table XI, p. 99, was formed, and which was strengthened by special examination — that there very probably exists, in addition to the short terms of twelve and fourteen months, another variation in latitude of much longer term, which is undoubtedly the same as that signalized by Nyrén and Gould, and gives the clue to Doolittle's singular results. Whether periodical or irregular is now uncertain. If the former, the cycle is somewhere between seven and fifteen years. Its discussion must be reserved until the completion of the investigation.

With this general explanation of the method of forming and solving the equations of condition — minor modifications of which may be made in special cases as they arise — let us now proceed to the discussion of the various series of observations. Only the more essential particulars will be given, fuller details being reserved for a memoir which will appear later.

§2. Peters's Vertical-Circle Observations of *Polaris*, 1842–44.

These observations are given by Peters to the end of April 1843, in his *Recherches sur la Parallaxe des Étoiles Fixes*. I have employed them as given by Gyldén in the introduction to vol. V of the Pulkowa Observations, continued to November 1844. Using the value of $\delta_0' = 88^\circ\, 28'\, 58''.49$ (see *Obs. de Poulk.*, IV, introd. p. (5)), corresponding to $\varphi'_0 = 59^\circ\, 46'\, 18''.67$, the values of n, eq. (26), were found for the 181 upper, and 191 lower culminations. These correspond exactly to the ns given by Nyrén in his *Memoir on the Latitude of Pulkowa*, pp. 17–23. Groups were then formed, for the culminations separately, comprising observations not over a week apart generally and rarely over ten days apart. These groups were so taken that their mean dates, for the two culminations, rarely differed more than two days. In doing this 13 u.c. and 13 l.c. observations had to be excluded for want of corresponding ones at the other culmination, thus reducing the weights from 499.6 to 462.4 for u.c., and from 537.8 to 502.7 for l.c. This slight sacrifice of material is far more than compensated for by the advantage that, in the discussion of the aberration and

parallax, the latitude-variation is completely eliminated, and *vice versa*, — as is shown by equations (31), (32) and (33). Taking the half-sums and half-differences of the simultaneous groups, we get the values of n_1 and n_2, eq. (34), and the mean dates and weights, in table I; the weights of course being taken equal to

$$\frac{w_u w_l}{w_u + w_l}$$

Peters's weights for the individual observations were used. The results for n and its products were carried to the third decimal place, but are here quoted only to the second.

Equations of condition were formed according to (32), using for the computation of the coefficients in (25), the values $\theta = 0^y.835$, and $T'_0 = 2394125$, obtained from (15). The 44 resulting observation-equations give the normal equations.

$$\begin{array}{rrrrrl}
+231.00x & -\ 55.81y & -\ \ 8.61z & +63.98\zeta & +\ \ 6.06\xi & = +6.20 \\
-\ 55.81 & +132.58 & -\ 30.47 & -41.71 & +\ 88.66 & = -6.35 \\
-\ \ 8.61 & -\ 30.47 & +\ 98.39 & -30.28 & -102.29 & = +1.80 \\
+\ 63.98 & -\ 41.71 & -\ 30.28 & +78.66 & +\ 18.93 & = -0.97 \\
+\ \ 6.06 & +\ 88.66 & -102.29 & +18.93 & +152.31 & = -8.93
\end{array}$$

the solution of which gives

$$\begin{array}{ll}
x = +0.0420 & \theta \cdot \Delta T = -14^d.5 \\
y = +0.0192 & \Delta T = -17^d.3 \\
z = -0.0743 & T'_1 = 2394108 \\
\zeta = -0.0368 & r_1 = 0''.077 \\
\xi = -0.1167 & G' = 17^\circ.5 \\
 & r_2 = 0''.122
\end{array} \Bigg\} \text{By eq. (30) and (25)}$$

whence, by eq. (24), the true value of the latitude at any observed date, t, is

$$\varphi = 59^\circ\ 46'\ 18''.712 - 0''.077 \cos(t - 1842\ \text{Sept. } 29) \times 0^y.835$$
$$(39) \qquad\qquad - 0''.122 \cos(\odot - 17^\circ.5)$$

Nyrén's value from these observations was 59° 46′ 18″.727.

With the values of n_2 in table I, we form equations of condition according to (33). The coefficients in the left-hand members of the normal equations [illegible] taken from the previous solution [illegible]

$$\begin{array}{rrrrl}
+231.00\xi & [illegible]\,Y & [illegible] & Z & = [illegible] \\
+\ 63.98 & +78.66 & +\ 18.93 & & = +0.72 \\
+\ \ 6.06 & +18.93 & +152.31 & & = -7.14
\end{array}$$

the solution of which gives

$$\xi = -0''.0011, \quad Y = +0''.0755, \quad Z = [illegible]$$

whence by (34), $a = +0''.0650$, $\pi = +$ [illegible] the definitive values of the aberration and parallax from this series are,

Aberration, **+20″.510** ; Parallax of *Polaris* **+0″.055**

The first differs inappreciably from **Nyrén**'s [illegible] The second is considerably nearer the [illegible] results obtained with this instrument, as will be seen when I have given the corresponding reductions of **Gyldén**'s and **Nyrén**'s observations. In this connection it may be well to note that the coefficients of x and ζ in the fifth and sixth of **Nyrén**'s normal equations (p. [illegible]) should be 1037.40 instead of 937.40, so that a strict comparison can not be made without correcting his solution [illegible] I also fail to reproduce the corresponding [illegible] **Gyldén**'s series on the same page; where, apparently, we should read 233.00 instead of 223.00, [illegible] and ζ. But the changes in the unknowns would be small.

As a matter of curiosity, the values of [illegible] by **Nyrén** have been corrected for the periodic term [illegible] its solution repeated with the corrected absolute terms of the normal equations; this gives in our present notation,

$$x = +0''.0420, \quad \xi = -0''.0091,$$
$$[illegible] = +0''.0480, \quad \pi = +[illegible].0644$$

But as the data are not entirely symmetrical [illegible] to culmination, and my examination was not [illegible] extreme care, these values are to be regarded only as [illegible] control of the definitive solution above given.

Table I. **Peters**'s Vertical-Circle Observations of *Polaris*, 1842-44.

t	w	n_1	r_1	n_2	r_2	t	w	n_1	r_1	n_2	r_2	t	w	n_1	r_1	n_2	r_2
1842		″	″	″	″	184[illegible]						[illegible]					
Mar. 14	4	+.15	+.14	+.30	+.27	Aug. 19	10	.01	.06	.04	.05	Apr. 26	7	+.02	[illegible]	[illegible]	[illegible]
20	5	+.05	+.06	.00	—.04	21	6	.0[illegible]	—.06	.07	.07	29	2	.0[illegible]	[illegible]	[illegible]	[illegible]
Apr. 3	3	—.20	—.18	—.13	—.18	Sept. 16	8	+.16	+.08	.05	.02	Sept. 14	11	+.17	[illegible]	[illegible]	[illegible]
10	3	—.01	.00	+.09	+.02	21	3	+.15	+.07	+.07	+.10	27	9	+.15	[illegible]	[illegible]	[illegible]
16	5	+.11	+.13	+.06	—.04	Oct. 4	3	+.04	—.0[illegible]	[illegible]	[illegible]	Oct. 6	[illegible]	+.2[illegible]	[illegible]	[illegible]	[illegible]
28	5	+.11	+.13	—.05	—.13	11	10	+.15	+.06	+.04	+.10	25	4	+.10	[illegible]	[illegible]	[illegible]
May 4	3	+.10	+.12	+.30	+.22	22	3	+.23	+.11	.10	.12	Nov. 18	2	+.11	[illegible]	[illegible]	[illegible]
14	3	+.01	+.06	+.18	+.09	Dec. 18	1	—.28	.34	[illegible]	+.13	Dec. 20	5	.28	[illegible]	[illegible]	[illegible]
24	3	+.05	+.07	+.0[illegible]	+.01	Feb. 1	2	.05	.06	.20	.17	Mar. 2[illegible]	[illegible]	+.12	[illegible]	[illegible]	[illegible]
28	3	—.07	—.05	+.12	+.04	18	5	.04	.04	[illegible]	[illegible]	A[illegible] 7	7	[illegible]	[illegible]	[illegible]	[illegible]
June 6	10	—.07	—.06	+.10	+.02	Mar. 7	3	.04	—.03	+.03	+.04	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	8	—.06	—.06	+.15	+.07	18	6	+.02	+.03	[illegible]	[illegible]	M[illegible]	6	[illegible]	[illegible]	[illegible]	[illegible]
July 6	7	+.02	.00	+.06	.00	21	7	.09	.08	.00	.04	Oct. 10	2	[illegible]	[illegible]	[illegible]	[illegible]
18	7	—.07	—.09	+.06	.00	Apr. 3	5	.04	.03	+.05	.04	31	2	[illegible]	[illegible]	[illegible]	[illegible]
Aug. 6	11	+.05	.00	—.02	—.05	18	8	.09	.02	+.08	+.04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

SUNSPOT OBSERVATIONS,

MADE AT THE HAVERFORD COLLEGE OBSERVATORY WITH THE 8-INCH EQUATORIAL,

BY W. H. COLLINS.

1892	Time	Grs.	Spots	Gr. Fac.	Def. and Size
July 2	2	3	20	0	poor
3	10	5	30	2	fair
4	9	1	53	3	good ; 2 large
5	9	3	77	1	fair, 1 large
6	8	3	63	0	poor, 5 large
7	9	5	92	2	fair, 1 large
8	9	7	169	2	good, 4 large
9	9	5	127	0	good, 7 large
10	10	5	131	2	good, 2 large
11	9	5	83	1	poor, 3 large
12	8	5	91	2	fair, 3 large
13	9	1	95	2	fair, 4 large
14	2	5	80	1	fair, 3 large
15	8	4	59	2	fair, 2 large
16	9	5	43	1	fair, 3 large
17	9	5	33	1	poor, 2 large
18	9	6	90	2	poor, 1 large
20	9	5	43	0	poor, 1 large
21	10	3	14	2	fair, 1 large
22	9	5	22	3	fair, 1 large
23	9	4	18	3	poor
24	9	5	38	1	good
25	8	7	56	1	fair
26	9	6	58	2	poor, 3 large
27	8	5	49	2	fair, 2 large
28	9	6	37	0	poor, 4 large
29	8	6	79	0	poor, 2 large
30	9	6	70	0	poor, 2 large
Aug. 3	9	5	79	0	fair, 3 large
4	9	4	71	1	fair, 3 large
5	9	6	66	3	fair, 2 large
30	9	5	52	3	fair, 2 large
31	2	5	30	3	fair, 3 large
Sept. 1	9	6	40	2	good, 2 large
2	9	5	30	2	poor, 2 large
3	8	5	29	1	poor, 2 large
4	2	4	21	1	bad, 2 large
5	9	4	15	2	poor, 1 large
6	9	4	10	2	fair
7	9	7	38	2	poor
9	11	5	54	2	poor
10	9	6	107	2	fair
11	9	5	85	2	poor
12	8	6	95	2	poor
13	11	4	57	2	bad
14	9	4	40	2	bad
15	8	6	41	1	fair, 1 large
16	9	5	41	0	poor, 1 large
17	8	5	28	1	poor, 1 large
18	9	6	29	2	poor, 1 large
19	8	4	43	1	fair
20	8	3	12	2	poor
21	10	3	19	1	poor
23	12	4	60	1	fair
Sept. 24	11	5	59	1	poor
25	9	5	47	2	poor
26	10	8	51	3	fair
27	10	7	106	3	good, 2 large
28	9	7	86	2	fair
29	11	6	60	1	fair
30	11	7	97	2	fair, 4 large
Oct. 1	10	7	94	0	fine, 1 large
2	9	6	60	0	poor, 2 large
3	9	7	100	2	fair, 1 large
5	9	7	109	1	poor, 2 large
6	9	5	77	2	fair, 1 large
7	10	5	118	2	fine, 1 large
8	9	5	94	2	good, 2 large
9	2	6	61	1	fair, 2 large
10	9	6	63	3	fair
11	10	2	40	1	good, 1 large
12	9	1	24	0	fair
13	2	3	72	0	fine
14	10	5	89	2	fine
15	10	6	59	1	fair, 1 large
16	9	4	41	0	fair
17	9	7	35	2	fair
18	10	2	21	0	fair
19	9	4	22	2	bad
20	10	5	43	1	poor
21	9	6	46	2	
22	9	7	51	2	fair
23	9	6	33	2	fair
24	8	7	28	1	poor
25	10	5	19	2	fair
26	11	3	28	1	good
27	10	3	33	3	good
30	10	5	79	1	fair, 2 large
31	12	7	115	1	good, 2 large
Nov. 1	10	7	89	2	good, 2 large
2	11	7	80	3	fair, 2 large
3	10	6	73	2	poor, 2 large
5	10	3	40	1	poor 5 large
6	9	4	46	3	poor, 2 large
8	3	3	42	2	good
11	9	4	13	1	poor
13	9	4	23	1	poor
14	10	3	37	1	fair
16	12	4	93	1	fair
17	9	3	87	1	good
19	12	3	38	0	poor, 2 large
20	9	3	51	2	fair, 2 large
21	4	5	69	2	good, 2 large
22	11	3	62	1	fair, 5 large
23	9	5	59	0	poor, 5 large
26	10	3	55	0	poor, 1 large
27	10	4	53	0	bad, 1 large
30	10	8	65	1	bad, 1 large

1892	Time	Grs.	Spots	Gr. Fac.	Def. and Size	1892	Time	Grs.	Spots	Gr. Fac.	Def. and Size
Dec. 1	9	10	64	1	fair, 1 large	Dec. 10	3	11	88	..	good, 5 large
2	11	9	39	3	poor, 1 large	11	9	8	71	..	fair, [illegible] large
3	11	7	60	1	good, 1 large	12	10	8	107	[illegible]	fair, [illegible] large
4	9	10	106	2	good, 1 large	18	9	2	20	1	bad
5	10	11	102	3	fair	20	12	2	10	1	poor
6	9	9	63	1	fair	21	3	3	27	1	fair
7	4	11	89	1	fair, 1 large	22	10	3	11	2	fair
9	10	9	80	3	fair, 3 large	23	12	3	14	0	bad

The observer was absent from August 5 to 30, and from December 23 to 1893 January 1.

OBSERVATIONS OF COMET *a* 1892 (*SWIFT*),

MADE AT THE OBSERVATORY OF THE STATE UNIVERSITY AT COLUMBIA, MISSOURI,

BY MILTON UPDEGRAFF.

1892 Columbia M.T.		✶	No. Comp.	☄ — ✶		☄'s apparent		[illegible] $p\Delta$	
	h m s			$\Delta\alpha$	$\Delta\delta$	α	δ	for [illegible]	
Mar. 10	17 38 41.6	1	5	—0 2.11	—1 23.6	19 17 42.96	—28 5 55.3	n9.4771	0.8769
11	17 13 39.1	2	7	—0 47.51	—2 21.6	19 22 22.99	—27 11 48.7	n9.5356	0.8622
12	17 14 2.8	3	8	+0 51.02	—6 0.5	19 27 5.99	26 21 33.1	n9.5550	0.8509
22	17 2 38.4	4	7	+1 53.18	—2 20.0	20 11 47.73	—16 39 55.1	n9.5370	0.8217
23	16 52 33.5	5	9	+1 6.98	+7 56.7	20 16 0.8	—15 38.1	n9.5531	0.8162
27	16 54 36.6	6	8	+0 33.69	—2 3.7	20 32 34.63	—11 26 42.9	n9.5132	0.8[illegible]8
30	16 44 20.6	7	8	—0 59.78	+4 36.0	20 44 33.3	— 8 16.6	n9.5561	0.7850
April 1	16 37 19.8	8	6	—5 59.17	+5 26.1	20 52 21.79	— 6 9 45.6	n9.5643	0.7747
5	16 27 17.7	9	6	—3 30.08	+5 10.9	21 7 33.58	— 1 58 27.1	n9.5754	0.7[illegible]
May 26	15 30 43.3	10	6	—0 37.17	—0 37.3	23 42 2.12	+35 21 50.2	n9.6761	0.3742
June 27	12 19 32.8	11	6	+0 38.13	+1 1.9	0 11 30.35	+15 50 21.7	n9.8190	0.5729
28	12 33 35.0	12	8	—2 6.06	—3 2.9	0 42 50.13	+46 1 49.6	n9.8189	0.5265
30	11 34 34.1	13	8	—1 32.61	+1 57.1	0 45 18.77	+46 32 31.9	n9.8205	0.6528
July 4	11 45 48.5	14	6	—3 52.13	+0 2.1	0 49 57.53	+47 26 11.6	n9.8315	0.5972

Mean Places of Comparison-Stars for 1892.0.

✶	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	19 17 46.17	—0.80	—28 4 25.9	— 5.8	½(2 Gould + Yarnall)
2	19 23 11.32	—0.79	—27 12 21.0	— 6.1	½(2 Gould + Yarnall)
3	19 26 15.75	—0.78	—26 15 26.2	— 6.1	Arg. Gen. Cat. no. 26761
4	20 9 51.91	—0.66	—16 37 26.2	— 8.9	Arg. Gen. Cat. no. 27753
5	20 14 51.1	—0.65	—15 45.8	— 9.1	S DM no. 5628
6	20 32 1.58	—0.64	—11 24 29.0	—10.2	Lal. 39756
7	20 45 33.7	—0.63	— 8 21.0	—10.6	S DM no. 5495
8	20 58 21.90	—0.61	— 6 15 1.1	—10.9	½(2 Gould + Yarnall)
9	21 11 1.25	—0.59	— 2 3 26.5	—11.5	Arg. Gen. Cat. no. 29195
10	23 42 39.91	—0.35	+35 22 38.9	—11.1	W. B. XXIII, 870
11	0 10 51.88	+0.34	+15 16 27.1	+7.6	Lal. 1250
12	0 44 56.11	+0.35	+46 7 59.9	+7.4	Lal. 1467 + [illegible] R. A.
13	0 46 51.01	+0.40	+46 30 12.2	+7.1	Lal. 14[illegible]
14	0 53 49.16	+0.50	+47 26 19.3	+6.8	Lal. 168[illegible]

The corrections for differential refraction have been applied. The observations of March 10, 11 and 12, have already been published in *A.J.* No. 260, but are inserted here on account of slight changes in the declinations due to change in the adopted value of [illegible]

[illegible] R. A. of Lalande [illegible] The comet's R. A. [illegible]

ON THE PROBABLE LARGE PARALLAX OF β *CYGNI*,

By HAROLD JACOBY.

The RUTHERFURD photographic measures of the stars about β *Cygni* contained in the sixth volume of the *Annals of the New York Academy of Sciences** exhibit certain discordances which can be explained on the hypothesis of a parallax for β *Cygni*, amounting to nearly a whole second of arc. I am aware that the evidence on this point cannot be regarded as conclusive, but it is sufficiently strong to make this star an object of especial interest and promise to parallax-observers. The RUTHERFURD measures are taken from six negatives, three of which were made 1875 July 26, and the other three 1875 Sept. 20. Each negative has two impressions, so that there are actually six observations for each date. I have selected from the RUTHERFURD list five pairs of comparison-stars, subject to the conditions that the two stars of each pair shall differ approximately 180° in position-angle with respect to the star β *Cygni*, and shall be at approximately equal distances from the same star. I have then computed the parallax separately from each pair of comparison-stars, in the usual manner, except that I have neglected the proper motion of β. This is given as $-0''.026$ in R.A., and $-0''.013$ in δ by AUWERS, and would therefore be quite inappreciable in the space of two months, which separates the two dates of observation. Moreover, under the circumstances, the proper motion could not be determined separately from the parallax.

My method of procedure will be plain from the table given below. It will be seen that I have used the *difference* of the distances of the two comparison-stars from β as the quantity from whose variation the parallax should appear. The distances are expressed in divisions of the glass scale of RUTHERFURD's measuring micrometer, and are fully corrected for refraction, etc. The numbers in the column, "Diff. of Distances," have received a small correction when necessary, to satisfy the scale-value condition that the "Sum of Distances" shall always be constant. This correction was always inappreciable, except in the case of the pair 2, 38, where it amounted to $0^d.0017$. Since there are only two dates of observation, we can get but two equations from each pair of comparison-stars. I have therefore not used least squares, but have in each case deduced at once the final equation for π by subtraction. This equation is given in the table, and it will be seen that some of the parallax-coefficients are of fair size. The final columns contain the parallax in scale and arc, one division of the scale being approximately equal to $28''.01$. I have given to each determination a weight equal to the parallax-coefficient in the corresponding equation, and find the weighted mean to be

$$\text{Parallax of } \beta\ Cygni = +0''.97$$

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*Contributions from the Observatory of Columbia College, No. 4.

Comparison Stars	Approximate Position-Angles	Date 1875	Distance		Sum of Distances	Diff. of Distances	Equation	Parallax of β		
			Star *a*	Star *b*				Scale	Arc	Wt.
12(*a*), 27(*b*)	221°(*a*), 45(*b*)	July 26	60.0836	55.4940	115.5776	4.5895	$+1.69\,\pi = +.0481$	+.0285	+0.80	1.69
		Sept. 20	.0568	.5155	.5723	.5414				
35(*a*), 3(*b*)	137(*a*), 306(*b*)	July 26	101.6974	100.8574	202.5548	0.8400	$+0.31\,\pi = +.0261$	+.0843	+2.36	0.31
		Sept. 20	.7070	.8409	.5479	.8661				
2(*a*), 38(*b*)	270(*a*), 112(*b*)	July 26	103.6737	78.9148	182.5885	21.7572	$+1.11\,\pi = +.0554$	+.0499	+1.40	1.11
		Sept. 20	.6324	.9323	.5647	.7018				
23(*a*), 22(*b*)	172(*a*), 3(*b*)	July 26	81.0177	74.7493	155.7670	6.2684	$+1.00\,\pi = +.0258$	+.0258	+0.72	1.00
		Sept. 20	.0053	.7627	.7680	.2426				
36(*a*), 8(*b*)	44(*a*), 220(*b*)	July 26	100.0193	98.6555	198.6748	1.3638	$+1.71\,\pi = +.0455$	+.0266	+0.74	1.71
		Sept. 20	.0149	.6356	.6805	.4093				

With regard to the reliability of the above determination, I wish, to a certain extent, to allow the evidence to speak for itself. No satisfactory explanation of the observations has occurred to me, except the hypothesis of parallax. I have purposely retained the pair 35, 3, which has a very small parallax-factor, in order to secure a very wide distribution in position-angle. This, I think, has been secured, and combined with the great constancy of scale-value, as evidenced by the close equality of "Sum of Distances" on the two dates, seems to negative any explanation based on possible shrinkage or distortion of the film. I am of opinion that β *Cygni* will be found to be one of our nearest neighbors among the fixed stars, so far examined for parallax.

Columbia College Observatory, 1893 *Jan.* 20.

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH REFRACTOR OF GOODSELL OBSERVATORY OF CARLETON COLLEGE, NORTHFIELD, MINN.

By H. C. WILSON.

(Communicated by Prof. W. W. PAYNE, Director.)

1892 Northfield M.T.		*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log *p*Δ	
				COMET *a* 1892 (SWIFT).					
	h m s			m s	′ ″	h m s	° ′ ″		
Apr. 5	16 57 40	1	6 , 6	+0 36.52	+ 8 11.6	21 7 38.55	− 1 57 2.0	9.491	0.79
22	15 24 33	2	12 , 4	+1 32.27	+ 5 12.0	22 6 38.95	+11 10 59.4	*n*9.606	0.7[illegible]
May 25	12 41 53	3	8 , 4	−0 30.49	+ 8 19.2	. . . .	. . . .	*n*9.704	0.726
	12 41 53	4	6 , 2	−0 56.35	− 0 7.6	. . . .	. . . .	*n*9.704	0.726
	12 41 53	5	2 , 2	−1 23.87	+ 4 32.1	. . . .	. . . .	*n*9.704	0.726
June 8	13 54 49	6	12 , 1	+2 5.63	− 4 35.1	0 10 0.07	+10 21 10.6	*n*9.729	0.566
	13 54 49	7	12 , 1	+1 5.01	− 1 7.5	0 9 59.58	+10 21 31.6	*n*9.729	0.566
Sept. 19	10 8 17	8	9 , 1	−1 37.33	− 1 19.6	0 17 41.25	+50 6 13.9	*n*9.551	*n*9.123
28	11 14 30	9	10 , 6	+0 15.90	− 0 58.4	0 6 39.52	+18 3 59.7	*n*8.704	*n*9.755
Oct. 19	10 36 40	10	9 , 6	−2 31.41	+ 4 18.1	23 49 2.33	+12 8 7.4	9.036	9.120
20	9 0 18	10	6 , 4	−3 3.18	−12 26.8	23 48 31.54	+11 54 22.6	*n*9.667	9.665
				WINNECKE'S COMET.					
Apr. 28	11 51 2	11	9 , 1	−2 23.62	+ 1 16.3	11 37 13.63	+43 19 58.2	9.586	0.06[illegible]
May 25	10 38 18	12	9 , 4	−3 15.02	+ 9 40.5	11 0 22.00	+43 57 26.2	9.665	0.329
Oct. 20	10 54 36	13	9 , 6	−2 19.63	+ 1 3.7	1 1 31.86	−26 25 1.5	*n*8.119	0.921
				COMET *d* 1892 (BROOKS, *Aug.* 28.)					
Sept. 28	12 30 21	14	6 , 6	+0 9.02	+ 3 0.8	7 22 5.38	+27 5 19.2	9.673	0.[illegible]
Oct. 20	12 27 12	15	12 , 6	−0 32.35	− 5 14.1	8 33 8.07	+18 38 23.9	*n*9.618	0.770
				COMET *e* 1892 (BARNARD).					
Oct. 20	8 2 37	16	9 , 6	−1 19.21	− 0 11.6	19 49 28.83	+ 9 54 32.8	9.372	0.7[illegible]

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	21 7 2.61	−0.59	− 2 5 1.9	−11.6	Munich II, 11334
2	22 5 7.22	−0.54	+11 6 0.6	−13.2	½(Schj. 9050 + Brux. 9901)
3	23 39 53.8	−0.36	+34 43.8	11.4	DM. 34 4998
4	23 40 20.4	−0.36	+34 51.4	11.4	DM. 34 4999
5	23 40 18.0	−0.36	+34 47.3	−11.1	DM. 34 5003
6	0 7 54.58	−0.14	+10 26 26.0	10.0	⅓(Radel. 29 + Yarnall-Frisby 7[illegible] + Brux. [illegible])
7	0 8 54.68	−0.14	+10 25 52.4	−10.0	½(Radel. 36 + Brux. 44)
8	0 19 15.63	+2.95	+50 7 15.7	+17.8	Goodsell Observatory Mer. Circ. Obs. [illegible]
9	0 6 20.69	+2.93	+18 1 40.6	+17.5	Bonn VI, 47 22
10	23 51 31.94	[illegible]	+12 3 25.8	[illegible]	½(Radel. 6226 + Gr. 10 Y. [illegible])
11	11 39 35.44	+1.81	+43 18 37.2	+ 4.7	½(Lal. 22215 + Weisse Bess. XI. [illegible])
12	11 3 35.89	+1.13	+43 47 35.6	+10.1	½(Radel. 2627 + Gr. 9 Y. [illegible])
13	1 3 18.24	+3.28	−26 26 22.6	+17.4	½(Wash. M. Z. 20[illegible] + M. Z. 7[illegible])
14	7 21 51.60	+1.67	+27 2 16.5	+ 1.9	2 Micrometer comp. with [illegible]
15	8 33 40.12	+1.88	+18 43 38.6	0.6	½(W. B. VIII, 788, [illegible] XIII[illegible])
16	19 50 16.50	+1.54	+ 9 51 38.4	+ 9.0	Munich I, [illegible] II, [illegible]

NOTES.

COMET *a* 1892 (SWIFT).

April 5. The comet is conspicuous to the naked eye, the head being equal to a fourth-magnitude star. The tail is faint but can be traced by averted vision to about 2° 30′, apparently perfectly straight. In the telescope the nucleus is not stellar, but is larger than the star-images, and has a bright, indefinite fan, making an angle of about [illegible] [illegible] remarked, almost [illegible]

April 22. [illegible] of finder field [illegible] I am very [illegible] and well-defined.

May 25. Comet bright = 8^M. Tail about two diameters of finder field (2° 30′) long.

June 8. Comet easily seen in finder in full moonlight. Faint tail, at least 30′ long.

Sept. 19. Easily visible in finder. Nucleus about 11^M.

Oct. 19. Comet easily seen in finder. Nucleus $10^M.5$. Head 1′ in diameter. Tail 3′ long, and spreading to 2′ width.

Winnecke's Comet.

April 28. Visible in 5-inch finder. About 2′ in diameter. Nucleus well-defined; about 11 mag.

May 25. Easily seen in 5-inch finder. Head at least 3′ in diameter. Nucleus well-defined; 11^M.

Oct. 20. Comet very faint, round, 1′ in diameter, with central condensation.

Comet *d* 1892 (Brooks).

Sept. 28. Comet brighter than when last observed. Strong condensation of nebulosity about the nucleus.

Oct. 20. Comet quite bright. Nucleus not very stellar, yet strongly condensed. Tail 9′ long.

Comet *e* 1892 (Barnard).

Oct. 20. Comet faint, round, 1′ in diameter, with central condensation. Nucleus 12^M. Comet barely visible in 5-inch finder. Barnard's comet was looked for on several later nights, but was not found.

For earlier observations of comets *a* and *d* 1892, see *Astr. Jour.* Nos. 262 and 275.

EPHEMERIS OF COMET *f* 1892 (*HOLMES*),

BY LEWIS BOSS.

(*Continued from A. J. No. 283.*)

The following ephemeris of comet *f* 1892 is founded upon the elements published on page 150, No. 283, of the *Astronomical Journal*. From an observation by Mr. Lay at the Dudley Observatory, the correction of this ephemeris for January 19.6 was: $\Delta\alpha = +1^s.9$; $\Delta\delta = -8''$.

Greenwich	App α	App δ	log Δ
	h m s	° ′ ″	
1893 Feb. 2.5	1 45 43.65	+33 49 34.3	0.42284
3.5	1 47 13.67	33 50 56.5	
4.5	1 48 44.28	33 52 23.1	0.42795
5.5	1 50 15.46	33 53 53.9	
6.5	1 51 47.21	33 55 28.9	0.43311
7.5	1 53 19.52	33 57 7.8	
8.5	1 54 52.37	33 58 50.6	0.43810
9.5	1 56 25.76	34 0 37.2	
10.5	1 57 59.68	34 2 27.4	0.44314
11.5	1 59 34.12	34 4 21.3	
12.5	2 1 9.07	34 6 18.6	0.44800
13.5	2 2 44.52	34 8 19.3	
14.5	2 4 20.46	34 10 23.2	0.45292
15.5	2 5 56.88	34 12 30.2	
16.5	2 7 33.77	34 14 40.1	0.45765
17.5	2 9 11.12	34 16 53.3	
18.5	2 10 48.92	34 19 9.1	0.46245
19.5	2 12 27.16	34 21 27.6	
20.5	2 14 5.84	34 23 48.7	0.46705
21.5	2 15 44.94	34 26 12.2	
22.5	2 17 24.46	+34 28 38.0	0.47171
Feb. 23.5	2 19 4.38	+34 31 6.0	
24.5	2 20 44.68	34 33 36.0	0.47618
25.5	2 22 25.37	34 36 8.1	
26.5	2 24 6.44	34 38 42.0	0.48071
27.5	2 25 47.87	34 41 17.6	
28.5	2 27 29.66	34 43 54.8	0.48504
Mar. 1.5	2 29 11.80	34 46 33.6	
2.5	2 30 54.28	34 49 13.7	0.48944
3.5	2 32 37.09	34 51 55.1	
4.5	2 34 20.24	34 54 37.8	0.49364
5.5	2 36 3.72	34 57 21.5	
6.5	2 37 47.52	35 0 6.3	0.49791
7.5	2 39 31.64	35 2 52.0	
8.5	2 41 16.07	35 5 38.5	0.50198
9.5	2 43 0.81	35 8 25.7	
10.5	2 44 45.85	35 11 13.6	0.50611
11.5	2 46 31.19	35 14 2.4	
12.5	2 48 16.81	35 16 51.1	0.51005
13.5	2 50 2.71	35 19 40.5	
14.5	2 51 48.89	35 22 30.3	0.51405
15.5	2 53 35.34	35 25 20.3	
16.5	2 55 22.06	35 28 10.4	0.51786
17.5	2 57 9.03	35 31 0.6	
18.5	2 58 56.26	35 33 50.8	0.52173
19.5	3 0 43.74	35 36 41.0	
20.5	3 2 31.45	35 39 31.1	0.52540
21.5	3 4 19.40	35 42 21.0	
22.5	3 6 7.57	+35 45 10.5	0.52914

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ASTRONOMICAL JOURNAL.

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OBSERVATIONS OF *MARS*, 1892,

BY A. HALL.

Deimos.

1892	Wash. M.T.	p	$\Delta\rho$	Δp	C—O	Wash. M.T.	s	$\Delta\rho$	Δs	C—O	N Comp.	Remarks
	h m	°				h m	"					
July 14	12 47.6	94.95	0.00	—0.03	—0.56	12 18.8	72.06	+0.02	+0.21	+1.98	8.3	
16	12 13.2	268.44	0.00	0.00	+0.02	12 41.8	80.08	+0.02	—0.19	—1.35	8.3	Very faint
18	12 58.7	73.74	—0.02	+0.01	+2.95	13 11.7	60.20	+0.02	+0.15	—2.57	1.2	clouds
19	12 11.0	102.72	—0.01	—0.03	—1.27	12 10.5	59.99	+0.02	+0.11	+2.53	8.3	
25	11 12.8	86.85	0.00	+0.01	+1.09	11 12.6	81.76	+0.02	+0.09	+0.29	8.3	
31	11 53.0	283.71	—0.01	—0.01	—2.09	11 53.1	65.68	+0.02	—0.02	+0.59	8.3	
Aug. 2	12 3.1	92.66	0.00	+0.01	+0.43	12 2.8	81.29	+0.02	+0.01	+0.60	8.3	cloudy
5	13 2.6	281.33	—0.01	—0.02	—2.56	13 2.6	66.46	+0.02	0.00	+0.88	8.3	faint
9	11 13.4	272.10	0.00	—0.02	—1.22	11 14.6	86.44	+0.02	+0.02	—0.89	8.3	
11	11 3.1	84.27	0.00	+0.03	+2.13	10 39.6	78.75	+0.02	—0.01	—1.06	8.3	clouds
12	10 36.2	109.64	+0.01	+0.07	—2.85	10 36.1	58.21	+0.02	—0.03	+2.59	8.3	
13	9 45.9	261.63	—0.01	—0.04	+0.27	9 45.9	65.37	+0.02	+0.07	—4.18	8.3	faint
14	10 52.4	278.01	—0.01	—0.05	—1.26	10 51.9	81.42	+0.02	+0.06	—0.15	8.3	faint
16	10 13.6	91.10	0.00	+0.05	+1.29	10 12.9	83.60	+0.02	—0.09	—0.09	8.3	
17	11 39.4	109.26	+0.01	+0.13	—2.75	11 39.1	51.24	+0.01	—0.08	+2.35	8.3	faint, [illegible]
18	9 15.2	266.16	0.00	—0.06	+0.50	9 16.9	75.70	+0.02	+0.13	—1.38	8.3	
19	10 34.3	283.18	—0.01	—0.10	—2.12	10 34.7	70.08	+0.02	+0.11	—0.05	8.3	[illegible]
23	9 46.2	270.46	0.00	—0.09	+0.29	9 55.8	78.08	+0.02	+0.20	—1.76	1.2	very faint.
28	9 36.2	270.26	0.60	—0.10	—0.96	9 35.1	80.21	+0.02	+0.29	—1.25	8.3	

Phobos.

1892	Wash. M.T.	p	$\Delta\rho$	Δp	C—O	Wash. M.T.	s	$\Delta\rho$	Δs	C—O	N Comp.	Remarks
	h m	°				h m	"					
July 14	13 14.1	273.92	0.00	+0.06	—2.15	13 14.8	30.28	+0.01	0.21	+0.72	8	
19	11 53.7	92.10	0.00	—0.01	—0.41	11 53.5	31.09	+0.01	+0.14	+0.97	8	
23	11 14.2	272.57	0.00	—0.01	—1.76	11 11.6	33.13	+0.01	—0.09	—0.03	8	
25	13 9.1	93.80	0.00	+0.02	+0.10	13 9.4	30.68	+0.01	+0.07	+1.48	8	
26	12 21.8	89.35	0.00	+0.03	+1.53	12 25.4	32.83	+0.01	+0.05	+0.74	8	
29	12 55.6	275.40	0.00	—0.02	—2.09	12 55.4	32.81	+0.01	+0.02	+0.54	8	
31	11 22.5	267.69	0.00	—0.03	+0.26	11 28.9	33.63	+0.01	—0.02	0.57	8	
Aug. 2	12 30.2	94.53	0.00	+0.03	+0.12	. . . .	. . . .	. . . .	. . . .	. . . .	4	
3	11 33.1	93.21	0.00	+0.03	+0.54	11 33.6	32.55	+0.01	+0.01	+1.2	8	
11	11 17.1	88.34	0.00	+0.06	+2.50	11 23.6	33.06	+0.01	+0.04	+0.47	7	[illegible]
12	9 55.9	93.51	0.00	+0.09	+0.14	9 56.1	33.20	+0.01	0.04	+0.71	8	
14	11 27.6	278.47	0.00	—0.13	2.00	11 25.9	31.31	+0.01	+0.06	+1.[illegible]	8	
15	10 42.6	275.37	0.00	—0.12	—1.88	10 44.9	34.72	+0.01	+0.07	—1.0[illegible]	8	
16	9 30.6	275.00	0.00	—0.11	+0.19	9 31.4	33.46	+0.01	+0.09	0.15	8	
17	12 4.9	96.10	0.00	+0.19	+0.97	12 5.9	29.84	+0.01	0.10	+2.15	8	[illegible]
18	10 57.1	97.69	0.00	+0.20	+0.86	10 57.8	29.64	+0.01	0.11	+1.[illegible]6	8	
19	10 12.8	94.81	0.00	+0.19	+0.78	10 12.9	31.64	+0.0[illegible]	—0.15	[illegible].28	8	
22	10 53.2	277.87	0.00	—0.25	1.57	10 52.1	31.41	+0.01	+0.17	[illegible].77	8	[illegible]

I am indebted to Capt. McNair, Superintendent of the Naval Observatory, for an invitation to observe *Mars* with the 26-inch refractor during the months of July and August. I was not able to begin these observations until nearly the middle of July; and the unfavorable position of the planet made it necessary to observe near the meridian only, and also caused frequent interruption by clouds and mist. The satellites, however, could be seen easily, and I think the preceding observations of them are fairly good. The method of observing was to make four settings of the position-circle, then to measure three double distances, and finally to turn back and make four more settings of the position-circle. In this way the means of the times for the angle and the distance will not differ much, unless there was interruption. The columns Δp, $\Delta\hat{p}$, and Δs give the corrections for differential refraction and the figure of the disk, and these have already been applied to the given values of p and s. The last corrections have been computed on the assumption that in bisecting the apparent disk of the planet the micrometer-thread passed through its center of gravity. In the columns C—O are given the residuals which I have found by computing the positions of the satellites from the data given by Marth, *Monthly Notices*, May, 1892. These residuals should of course be checked by an independent computation before they are used. Those for the outer satellite indicate perhaps a correction to the position of its orbit-plane, but on the whole they are so small for both satellites, that it is not worth while at present to undertake a correction of the orbits. A definitive computation of these orbits should be made after the opposition of 1894, when the planet will be in a much better position for observing at the northern observatories. Then a complete discussion of the observations will determine the motions of these satellites with great accuracy. According to my estimates, the inner satellite is decidedly brighter than the outer one.

The South Polar Spot.

The angle of position of this spot was measured by placing the wire on the center of the spot and bisecting the apparent disk of the planet. Four such settings were made at each observation. At first this spot was very much extended, as is shown by the measures given below, and the image of the planet was in most cases poorly defined, so that the observation was not very satisfactory. It may be doubted whether the shrinkage of the spot was symmetrical with respect to its center, although the rotation of the planet would tend to produce such a result. I have however assumed this to be the case, and have formed the equations of condition under this assumption. The correction for the figure of the disk has been computed, but has not been applied to the observed angles given below. After correcting these angles they have been compared with the position of the south pole of the planet given by Marth. The question of condition for the residuals is

$$x + by + cz + n = o.$$

where x is the correction to Marth's position of the pole for epoch Aug. 6.0; and

$$y = r\cos\theta, \quad z = r\sin\theta;$$

r being the angular distance from the pole to the center of the spot. The daily rotation of the planet has been taken equal to 350°.89211, and the coefficients b and c are the cosines and sines of angles found by carrying the position backward and forward from the epoch by means of the above motion, n is the quantity C—O and the column Residual gives the result of substituting the values of the unknown quantities found from the least-square solution.

1892		Wash. M.T.	p	Δp	C—O	b	c	Residual	Remarks
		h m	°	°				°	
July	12	11 55.4	178.4	—1.3	+1.1	—0.456	—0.890	+1.66	Thin clouds; spot very large
	14	13 31.8	180.1	—1.1	—1.0	—0.536	—0.841	—0.19	Misty
	15	12 43.8	177.9	—1.0	+1.5	—0.201	—0.980	+1.37	Clouds
	19	12 25.2	176.8	—0.7	+2.6	+0.491	—0.871	+1.25	
	21	13 52.7	178.3	—0.6	+1.3	+0.442	—0.897	0.00	Thin clouds
	23	11 56.6	178.3	—0.4	+1.3	+0.955	—0.296	+0.04	
	25	12 17.1	179.7	—0.3	+0.1	+0.998	—0.070	—0.83	Hazy
	26	13 8.6	182.5	—0.3	—2.7	+0.991	—0.130	—3.73	Hazy
	29	12 2.1	183.6	—0.1	—3.4	+0.808	+0.589	—2.74	The spot indistinct
Aug.	2	11 35.6	185.1	—0.1	—1.3	+0.191	+0.981	—1.66	
	3	11 43.2	183.8	0.0	—3.0	+0.066	+0.998	—0.08	
	4	11 31.6	183.4	0.0	—2.4	—0.129	+0.992	+0.91	Hazy
	5	12 40.1	185.5	0.0	—4.4	—0.009	+1.000	—1.32	
	6	11 16.1	181.8	0.0	—0.5	—0.503	+0.865	+3.35	Blazing images, and haze
	9	11 23.1	185.4	+0.1	—3.7	—0.827	+0.563	+0.27	
	11	11 38.6	184.3	+0.2	—2.4	—0.941	+0.339	+1.39	
	12	11 4.4	186.1	+0.2	—4.0	—0.999	+0.011	—0.63	
	13	10 12.4	184.9	+0.3	—2.8	—0.943	—0.333	—0.22	clouds
	14	11 4.9	185.9	+0.3	—3.6	—0.963	—0.271	—0.87	A little mist, but good images
	15	10 43.1	183.5	+0.4	—1.2	—0.865	—0.503	+0.91	Blazing images
	16	10 32.4	184.8	+0.4	—2.3	—0.745	—0.667	—0.74	

1892		Wash. M.T.	p	Δp	C − O			Res. Eq.	Remarks
		h m							
Aug.	17	11 22.9	185.5	+0.5	−5.0	−0.781	−0.625	−1.29	
	18	10 45.9	182.2	+0.6	+0.4	−0.548	−0.837	+1.25	
	19	10 49.4	185.6	+0.6	−2.9	−0.422	−0.907	−2.44	
	22	10 24.1	183.8	+0.9	−1.1	+0.118	−0.989	−1.96	
	23	9 40.8	179.4	+1.0	+3.3	+0.472	−0.881	+1.97	
	28	9 51.9	181.2	+1.4	+1.5	+0.946	−0.325	+0.21	
	29	9 51.4	180.5	+1.6	+2.1	+0.986	−0.169	+1.01	
	30	9 14.4	178.5	+1.7	+4.0	+0.989	+0.146	+3.48	
Sept.	1	9 43.1	182.3	+1.8	+0.2	+0.912	+0.334	+0.12	Blazing images
	2	9 20.4	181.8	+1.9	+0.6	+0.847	+0.531	+1.07	Strong moonlight
	16	7 55.8	185.3	+3.3	−4.8	−0.999	−0.042	−1.58	

Giving the weight unity to each of the equations of condition, we have the normal equations:

$$+32.000\,x - 0.595\,y - 1.148\,z - 33.500 = 0,$$
$$+17.290\,y + 1.832\,z + 32.938 = 0,$$
$$+11.712\,z - 17.840 = 0.$$

The solution gives

$$x = +1''.244 \pm 0''.207; \quad y = -2''.055 \pm 0''.276;$$
$$z = +1''.819 \pm 0''.306.$$

We have

$$[nn.3] = 83.24 \text{ and } \Sigma pvv = 83.53$$

The probable error of an observation is ±1″.145 = ±0°.234, at the average distance. The correction to MARTH's position of the axis of the planet is therefore +1°.24, and the distance of the center of the spot from this axis is 2°.745 ±0°.290. It is interesting to compare the determinations of the distance of this spot from the pole of the planet. They are as follows:

Herschel,	1783	= 8 8
Bessel,	1830	= 6 56
Beer & Mädler,	1837	= 8 0
Secchi,	1858	= 17 42
Linsser,	1862	= 20 0
Kaiser,	1862	4 16
A. Hall,	1877	5 11
Schiaparelli,	1877	6 9
A. Hall,	1892	2 45

WIDTH OF THE SPOT

In order to determine the change in the extent of the spot, the angle it subtended at the center of the planet was measured. The results are as follows:

1892 July 14, angle = 16.5 [illegible]
Aug. 12, " = 25.8 [illegible]
Sept. 16, " = 20.9 [illegible]

During the last part of the observations, when the spot had become small, its center had the appearance of a depression or cavity in the surface of the planet. This may have been only a subjective phenomenon depending on the observer; but my experience was the same in 1877.

THE SURFACE OF THE PLANET

On account of the unfavorable position of [illegible] at this opposition, the markings on its surface were [illegible] indistinct, and it would not bear the [illegible] powers except on a few nights. My observations were nearly all [illegible] with a magnifying power of 400. On Aug. 14 and [illegible] [illegible] would bear a power of 600, but this did not show [illegible] of surface than the 400. On Aug. 18, I [illegible] region around the north pole of the planet [illegible] ance continued during the rest of the observations. W[illegible] the images were good [illegible] could be seen, but no [illegible] could be made out among the [illegible]. [illegible] part of the opposition the images of the planet [illegible] indistinct, [illegible] conditions gave [illegible] and color to some of [illegible] it would be easy to [illegible]. No doubt there were [illegible] spots but [illegible] and careful study to [illegible] place.

REVOLUTION OF THE MICROMETER-SCREW

[illegible]

R = [illegible]

[illegible]

R = [illegible]

[illegible]

Years	Stars	Nights	R	Wt.
1880–1883	*Celaeno* and *Electra*	21	9.9356 ± 0.000136	4
1883–1884	*h Persei*, Krüger nos. 20, 22	11	9.9359 ± 0.000252	3
1890–1891	*Celaeno* and *Electra*	6	9.9381 ± 0.000765	1
1891	ι^1 and ι^2 *Bootis*	5	9.9358 ± 0.002813	1

The resulting value from these measurements, is

$$R = 9''.9360 \pm 0''.000294$$

The declinations of *Celaeno* and *Electra* in the first series were taken from all the standard authorities and reduced to the time of the observations, but in the series for 1890–1891 these declinations were taken from Newcomb's Zodiacal Catalogue. The positions of the stars in *h Persei* were the best I could find, and the declinations of ι *Bootis* were taken from the *Berliner Jahrbuch*. These observations were made near the meridian, since I found there was an apparent flexure of the mounting that made the difference of declination for northern stars uncertain at large hour angles. As this value of a revolution of the screw was determined in a manner similar to that in which distances were measured, I think it is the right value to use in reducing all my observations with the 26-inch refractor.

Washington, 1893 *Jan.* 7.

OBSERVATIONS OF COMET g 1892 (*BROOKS*),

MADE AT THE VASSAR COLLEGE OBSERVATORY.

BY MARY W. WHITNEY AND MARY S. WAGNER, STUDENT-ASSISTANT.

1893	Poughkeepsie M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ	Obs.
	h m s			m s	′ ″	h m s	° ′ ″			
Jan. 10	7 52 24	1	5	—0 18.04	—1 33.9	21 3 21.81	+62 27 57.3	9.979	0.179	W.
11	7 23 49	2	4	—0 13.10	—0 25.1	21 23 15.25	+61 6 0.2	9.956	9.715	W.
	8 7 22	2	3	+0 23.13	—2 51.0	21 23 51.78	+61 3 31.6	9.960	0.532	Wa.
13	7 9 36	3	4	+3 53.43	—2 46.7	21 56 37.36	+58 1 33.8	9.899	0.132	W.
16	7 31 31	4	6	+0 17.87	—1 9.5	22 33 19.37	+53 20 53.1	9.845	0.252	W.
	9 44 37	5	12	—0 13.68	—1 33.0	22 35 41.01	+53 15 48.7	9.855	0.680	Wa.
17	7 36 23	6	6	—3 12.58	+7 7.0	22 42 16.46	+51 49 17.8	9.829	9.938	W.
	9 52 4	6	3	—2 49.63	—1 20.6	22 43 39.41	+51 40 50.2	9.837	0.697	Wa.

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	21 3 43.32	—3.47	+62 29 31.7	—0.5	Krueger, A.G. Zones
2	21 23 31.65	—3.30	+61 6 24.9	+0.7	Krueger, A.G. Zones
3	21 53 6.91	—2.98	+58 7 18.2	+2.3	Krueger, A.G. Zones
4	22 33 1.03	—2.53	+53 21 58.7	+3.9	Bonn VI, 53°2935
5	22 35 57.23	—2.51	+53 17 17.6	+4.1	Greenwich 1880, 3807
6	22 46 31.43	—2.39	+51 42 6.4	+4.4	Cambridge, A.G. Zone

EPHEMERIS OF COMET g 1892, (*BROOKS*).

BY PHILLIPS ISHAM.

(*Continued from A.J., No. 286.*)

Gr. M.T.	App. α	App. δ	log r	log Δ	Br.	Gr. M.T.	App. α	App. δ	log r	log Δ	Br.
1893	h m s	° ′				1893	h m s	° ′			
Feb. 7.5	0 7 56	+31 4.7	0.1123	0.1663	1.5	Feb. 16.5	0 22 48	+26 41.8			
8.5	9 51	30 30.2				17.5	24 13	26 18.0	0.1341	0.2447	0.9
9.5	11 41	29 57.4	0.1164	0.1834	1.3	18.5	25 34	25 55.3			
10.5	13 26	29 25.9				19.5	26 51	25 33.3	0.1388	0.2583	0.9
11.5	15 8	28 55.8	0.1206	0.1998	1.2	20.5	28 11	25 12.1			
12.5	16 46	28 26.7				21.5	29 26	24 51.7	0.1436	0.2713	0.8
13.5	18 21	27 58.8	0.1250	0.2154	1.1	22.5	30 40	24 32.1			
14.5	19 53	27 32.2				23.5	0 31 52	+24 13.1	0.1485	0.2838	0.7
15.5	0 21 21	+27 6.6	0.1295	0.2304	1.0						

SUNSPOT OBSERVATIONS,

MADE AT PHILADELPHIA, PENN., WITH A 4½-INCH REFRACTOR

BY A. W. QUIMBY.

1892		Time	New Grs.	Total Grs.	Total Sps.	Fac. Grs.	Definition
July	1	1		3	21	2	poor
	2	2	1	4	22	3	fair
	3	8		3	19	3	fair
	4	8	1	4	14	4	fair
	5	8		3	97	3	fair
	6	8		3	109	3	fair
	7	8	2	4	145	3	fair
	8	7	2	7	253	4	good
	9	7		7	198	3	fair
	10	7		6	257	4	good
	11	7		6	126	3	fair
	12	7		5	137	3	fair
	13	6		5	97	4	fair
	14	3	1	5	153	4	fair
	15	7		5	57	2	fair
	16	7	2	6	68	4	fair
	17	7		6	74	3	fair
	18	7		6	103	3	fair
	19	8		6	33	–	very poor
	20	8		6	52	5	fair
	21	7	1	4	22	4	poor
	22	7		6	26	7	fair
	23	8		5	23	4	fair
	24	7	1	5	15	3	fair
	25	7	2	7	14	4	fair
	26	7	2	9	87	3	fair
	27	7	1	8	54	3	fair
	28	7		7	68	3	fair
	29	9		9	127	2	fair
	30	7	1	6	32		very poor
Aug.	1	12	1	7	27	–	very poor
	3	7		9	132	4	fair
	4	7		9	96	3	poor
	5	7	2	8	67	4	fair
	6	7	1	7	34	4	fair
	7	7	1	7	75	4	fair
	8	7		7	63	5	fair
	9	7		6	47	6	fair
	10	7	1	7	32	4	fair
	11	8		8	85	4	fair
	12	8		6	32	4	fair
	13	7	2	9	56	3	fair
	14	7		9	102	3	good
	15	9		9	97	4	fair
	16	9		10	80	5	fair
	17	8		9	82	5	fair
	18	8		8	152	4	fair
	19	7		6	123	4	fair
	20	7	2	7	151	4	fair
	21	7	2	10	107	5	poor
	22	8		9	76	5	fair
	23	9		7	67	3	poor
	24	8		6	47	4	poor
	25	8	1	7	43	4	poor
	26	10		1	15	–	very poor

1892		Time	New Grs.	Total Grs.	Total Sps.	Fac. Grs.	Definition
Aug.	27	8	2	6	27	[illegible]	[illegible]
	28	8		6	31	4	[illegible]
	29	8		5	34	[illegible]	[illegible]
	30	9		5	[illegible]	[illegible]	[illegible]
	31	10		4	31	–	[illegible]
Sept.	1	7	1	5	21	[illegible]	[illegible]
	2	7		4	[illegible]	2	[illegible]
	3	9	1	5	27		[illegible]
	4	8		4	25	2	[illegible]
	5	8		1	21	3	[illegible]
	6	8	1	5	21	[illegible]	[illegible]
	7	9	2	7	[illegible]	4	[illegible]
	8	8		4	[illegible]	–	[illegible]
	9	8	1	4	51	–	[illegible]
	10	8	1	5	[illegible]	[illegible]	[illegible]
	11	8	1	6	[illegible]	[illegible]	[illegible]
	12	8		5	[illegible]	[illegible]	[illegible]
	13	8		5	71	2	[illegible]
	14	8	1	5	[illegible]	[illegible]	[illegible]
	15	8	1	[illegible]	[illegible]	1	[illegible]
	16	8		5	[illegible]	4	[illegible]
	17	8	2	6	[illegible]	4	[illegible]
	18	8	1	7	[illegible]	[illegible]	[illegible]
	19	8		8	[illegible]	[illegible]	[illegible]
	20	8		[illegible]	[illegible]	4	[illegible]
	21	8		4	[illegible]	[illegible]	[illegible]
	22	10		2	[illegible]		[illegible]
	23	10	1	4	[illegible]		[illegible]
	24	[illegible]		4	[illegible]	[illegible]	[illegible]
	25	9		4	[illegible]	2	[illegible]
	26	10	[illegible]	7	41	[illegible]	[illegible]
	27	8		8	74	[illegible]	[illegible]
	28	8		7	[illegible]	4	[illegible]
	29	10		6	[illegible]	4	[illegible]
	30	2		4	[illegible]	[illegible]	[illegible]
Oct.	1	9		4	74	–	[illegible]
	2	8	1	[illegible]	[illegible]	[illegible]	[illegible]
	3	10	1	5	[illegible]		[illegible]
	4	8		5	[illegible]	[illegible]	[illegible]
	5	8	2	[illegible]	[illegible]	5	[illegible]
	6	12		5	[illegible]	2	[illegible]
	7	12	1	6	[illegible]	4	[illegible]
	8	9	1	6	[illegible]	4	[illegible]
	9	9	1	7	[illegible]	4	[illegible]
	10	9		[illegible]	[illegible]		[illegible]
	11	11		7	[illegible]		[illegible]
	12	11		3	[illegible]	4	[illegible]
	13	[illegible]		4	[illegible]		[illegible]
	14	9	2	4	[illegible]	4	[illegible]
	15	[illegible]	1	6	[illegible]		[illegible]
	16	8		4	[illegible]		[illegible]
	17	8	1	5	[illegible]	[illegible]	[illegible]
	18	11	1	5	[illegible]		[illegible]
	19	10		6	[illegible]		[illegible]

1892	Time	New Grs.	Total Grs.	Total Sps.	Fac. Grs.	Definition
Oct. 20	12	2	6	80	3	very good
21	11		6	43	3	poor
22	9	1	7	76	4	good
23	9		4	37	1	fair
24	9		4	15	4	fair
25	9	1	5	13	1	poor
26	12		4	13	4	poor
27	12	1	5	29	1	fair
28	9		4	76	3	fair
29	9		6	93	3	fair
30	8	1	7	111	4	fair
31	8	1	7	81	3	fair
Nov. 1	8		6	66	3	poor
2	8	1	7	57	1	poor
3	10		1	109	3	fair
4	3		3	31	3	poor
5	12		3	51	3	fair
6	9		3	52	1	fair
7	10		2	15	–	very poor
8	9		2	23	2	poor
9	10		1	9	–	poor
10	12		1	5	–	very poor
11	9	3	1	11	3	poor
12	10		1	5	–	very poor
13	10	1	4	17	3	poor
14	10		3	11	1	fair
16	12		3	17	2	fair
17	10		2	57	2	fair
18	11	1	3	36	1	poor
19	9	1	1	67	2	fair
20	9		3	38	2	poor
21	9	1	3	40	2	poor
22	9	1	4	16	2	poor
23	9	1	6	60	3	poor
Nov. 24	9		5	43	3	poor
25	10		3	59	3	fair
26	12		2	19	4	poor
27	12	2	4	56	3	fair
29	9		4	51	2	poor
30	12	1	8	47	4	poor
Dec. 1	8	1	7	44	2	poor
2	8	1	8	39	3	poor
3	12	1	11	59	3	poor
4	10	1	10	78	3	poor
5	10	1	10	77	3	fair
6	10	1	8	48	1	poor
7	9		10	23	1	poor
8	8	1	8	19	1	poor
9	9	1	12	62	1	fair
10	1		12	39	3	poor
11	9		9	58	1	poor
12	9		7	78	5	fair
14	12		4	7	2	poor
16	9		1	7	1	poor
18	9		2	11	2	poor
19	9	1	3	7	2	poor
20	11		1	17	1	poor
21	12		3	20	1	fair
22	10		3	28	4	fair
23	1	1	4	17	2	poor
24	9	1	5	36	2	poor
26	9		5	45	2	poor
27	1	2	6	48	2	poor
28	10		5	67	2	poor
29	9		5	35	2	poor
30	12	1	5	16	3	poor
31	1		5	11	2	poor

ON THE SPECTRA AND PROPER MOTIONS OF STARS.

By W. H. S. MONCK.

I lately supplied to the *Astronomical Journal* the result of my examination of the spectra of Professor PORTER's list of 301 stars having a proper motion of over half a second annually. I have since then compared the *Cincinnati Catalogue* of 1340 stars with large proper motion with the *Draper Catalogue*, and succeeded in identifying 475 of them. The result as regards spectra is as follows: A, 85 stars; B, 1 star; E, 70 stars; F, 146 stars; G, 9 stars; H, 105 stars; I, 21 stars; K, 30 stars; M, 4 stars.

From the introductory volume to the *Draper Catalogue* I learn that the spectra contained therein are distributed as follows: A, 5218 stars; B, 99 stars; E and G (classed together), 1271 stars; F, 1080 stars; H, I and K (classed together), 2562, and M, 88 stars. Hence it appears that the percentage of stars with each kind of spectrum having sufficient proper motion to appear in the *Cincinnati Catalogue* (viz., about 0″.15 annually) is as follows:

Spectrum A,	1.63 per cent.
Spectrum B,	1.01 "
Spectra E and G,	6.21 "
Spectrum F,	13.52 "
Spectra H, I and K,	6.21 "
Spectrum M,	4.54 "

There are 27 stars with peculiar spectra in the *Draper Catalogue*. None of them appear in the *Cincinnati Catalogue*.

I may remark, that owing to the large proper motions of the solar stars (E to K inclusive), the stars used in determining the sun's motion in space usually belong to this class. If Professor PICKERING is right in thinking that the Milky-Way is a distinct system consisting, mainly at least, of Sirian stars, none of the determinations of the sun's motion hitherto made can be relied on as giving its motion relative

to the Galaxy. Possibly, however, the fact that we obtain a more northerly apex for the sun's way, when we employ stars with smaller proper motion, arises from the proportion of Galactic stars used in [illegible] It would [illegible] with different kinds of spectra give [illegible]

ON THE PARALLAX OF β CYGNI.

BY F. GERTRUDE WENTWORTH.

A parallax as large as that indicated in no. 287 ought to be distinctly evident in good meridian-circle observations. Since the parallactic motion is greater in right-ascension, I have taken as a suitable test of the question the observations of this coordinate from 1861 to 1869 from the *Pulkowa Annals*, XII, p. 192. Subtracting 0ˢ.013 from the first four (eye-and-ear) observations, and adding the same quantity to the last fifteen (chronographic) observations, to make them homogeneous, we thus get the following equations of condition.

$1 \cdot \Delta\alpha + 1.06\,\pi - 0.36\,\Delta k + 1.23 = 0$
$1 \quad + 1.12 \quad + .01 \quad + 2.02 = 0$
$1 \quad + 1.12 \quad - .05 \quad + 0.28 = 0$
$1 \quad - 1.03 \quad + .13 \quad + .36 = 0$
$1 \quad - 1.12 \quad - .10 \quad - .52 = 0$
$1 \quad - 1.10 \quad - .18 \quad - .30 = 0$
$1 \quad - 0.82 \quad + 0.77 \quad - .80 = 0$
$1 \quad - 0.23 \quad - 1.10 \quad + .80 = 0$
$1 \quad - 1.10 \quad + 0.19 \quad - .22 = 0$
$1 \quad - 1.12 \quad + .09 \quad - .52 = 0$
$1 \quad - 1.01 \quad - .39 \quad - .08 = 0$
$1 \quad - 0.86 \quad + .73 \quad - 0.12 = 0$
$1 \quad - 0.88 \quad + .70 \quad - 1.47 = 0$
$1 \quad + 1.08 \quad - 0.28 \quad - 0.10 = 0$
$1 \cdot \Delta\alpha - 1.09\,\pi + 0.25\,\Delta k$ [illegible] 7 [illegible]
$1 \quad - 1.04 \quad + .41$ [illegible]
$1 \quad - 0.99 \quad + .52$ [illegible] $= 0$
$1 \quad - 1.08 \quad + .30$ [illegible] $= 0$
$1 \quad - 1.12 \quad + 0.07$ [illegible] $= 0$

The solution of the chronographic [illegible] gives

$$\pi = -0''.268\ (\pm 0''.188) [illegible]$$

Similarly, from all the data together, we get,

$$\pi = -0''.663 \pm 0''.127 [illegible]$$

From this it is evident that, whatever [illegible] aberration, the testimony of these observations [illegible] against the existence of any appreciable parallax [illegible] star. If we assume a hypothetical parallax [illegible] sum of the squares of the residuals [illegible] 3″.7 to 25″.7 for the chronographic observations [illegible] 6″.6 to 53″.6 for all. It does not seem [illegible] the data by a more refined, different [illegible] evidence, in any event, seems to [illegible] that derived from photographic [illegible] only 56 days apart.

1893 *February* 3.

OBSERVATIONS OF COMET g 1892.

MADE AT THE CINCINNATI OBSERVATORY.

BY J. G. PORTER.

1893 Cincinnati M.T.	✱	No. Comp.	☾ − ✱ Δα	Δδ	☾'s apparent α	δ	[illegible]
Jan. 15 9ʰ 1ᵐ 44ˢ	1	6 , 6	+2 8.25	+4 9.4	22 23 42.71	+54 [illegible]	[illegible]
17 7 49 14	2	12 , 8	−0 16.38	−2 5.0	22 43 9.29	+51 [illegible]	[illegible]
19 6 40 9	3	6 , 4	+0 23.05	−1 52.3	22 58 42.5	+48 [illegible]	[illegible]
6 40 9	4	6 , 4	[illegible] 3 41.78	+0 30.5	22 58 43.0	+48 [illegible]	[illegible]
23 6 18 58	5	12 , 6	[illegible] 2 31.32	[illegible] 5 44.6	23 22 26.4	+43 47 29.4	[illegible]

Mean Places for 1893.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	[illegible]	[illegible]
1	22 21 37.13	−2.64	+54 41 17.6	+3.7	R[illegible] A.G.Z. [illegible]
2	22 43 28.08	2.41	+51 47 55.[illegible]	+4.3	[illegible] with R[illegible] A.G.
3	22 58 21.71	−2.24	+49 0 34.7	+4.2	B.B. VI. [illegible]
4	23 2 26.90	2.22	+48 55 15.3	+4.5	O. Arg. [illegible]
5	23 25 0.22	1.96	+43 51 2.0	+4.0	Weisse's Bess. XXIII. [illegible]
a	20 50 4.54	−3.56	+63 14 26.3	[illegible]	[illegible]

NOTES.

The star (a) is the one used on Jan. 9.

Jan. 15. Temperature 10° below zero. Chronograph pen frozen. Δα by eye-and-ear.

Jan. [illegible] Ha[illegible]

Jan. [illegible] Comet [illegible]

NEW ASTEROIDS.

Prof. KREUTZ has transmitted the positions of five small planets discovered in January, 1893.

A. CHARLOIS, Jan. 17. 9^M.

1893 Jan. 18 8^h $30^m.1$ Nice M.T. $\alpha = 8^h\ 8^m\ 59^s.3$, $\delta = +9^\circ\ 29'\ 12''$. Daily motion, -52^s in α, and $9'$ northward.

B. WOLF, Jan. 12. 13^M.

1893 Jan. 12 9^h 53^m Greenw. M.T. $\alpha = 8^h\ 15^m.6$, $\delta = +11^\circ\ 52'$
Jan. 19 11 51 Heidelberg M.T. 8 7 .3, +15 6'

C. WOLF, Jan. 16. 13^M.

1893 Jan. 16 12^h 47^m Greenw. M.T. $\alpha = 9^h\ 11^m.3$, $\delta = +17^\circ\ 11'$. Daily motion, $-0^m.9$ in α, and $1'$ northward.

D. WOLF Jan. 12, and CHARLOIS Jan. 18. $12\frac{1}{2}^M$.

1893 Jan. 12 $\alpha = 8^h\ 25^m.8$ $\delta = +15^\circ\ 25'$
19 11^h $54^m.0$ Heidelberg M.T. 8 20 .0 +16 5
20 8 31 .1 Nice M.T. 8 19 $15^s.1$ +16 12 29''

E. CHARLOIS, Jan. 20. $12\frac{1}{2}^M$.

1893 Jan. 21, 8^h $19^m.3$ Nice M.T. $8^h\ 28^m\ 3^s.7$, $+25^\circ\ 1'\ 56''$. Daily motion, -1^m in α, and $2'$ northward.

ASTRONOMICAL JOURNAL PRIZES.

The commission of Judges designated for the award of these prizes consists of Messrs. ASAPH HALL, SETH C. CHANDLER, and LEWIS BOSS.

Two additional prizes are hereby offered, for the year 1895, subject to the same conditions as were prescribed on page 160 for those of the year 1894.

I.

For the observer making, by ARGELANDER's method, the best series of determinations of maxima and minima of variable stars during the two years ending 1895 March 31, a prize of two hundred dollars. A principal basis for the award is to be the extent to which the determinations will contribute to our better knowledge of the periodic variables, by furnishing the largest number of maxima or minima of the largest number of stars, having especial regard to stars whose characteristics are at present not very well known.

II.

For the most thorough discussion of the theory of the rotation of the Earth, with reference to the recently discovered variations of latitude, a prize of four hundred dollars. The manuscript (which will be returned to the author) is to be transmitted to some one of the Judges, not later than 1895 March 31.

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TO THE TWELFTH VOLUME

The Notation of Recently Confirmed Variables is Adopted from Dr. CHANDLER'S forthcoming Catalogue.

PLATE FOR VOL. XII. Page [illegible] Variation of Latitude.